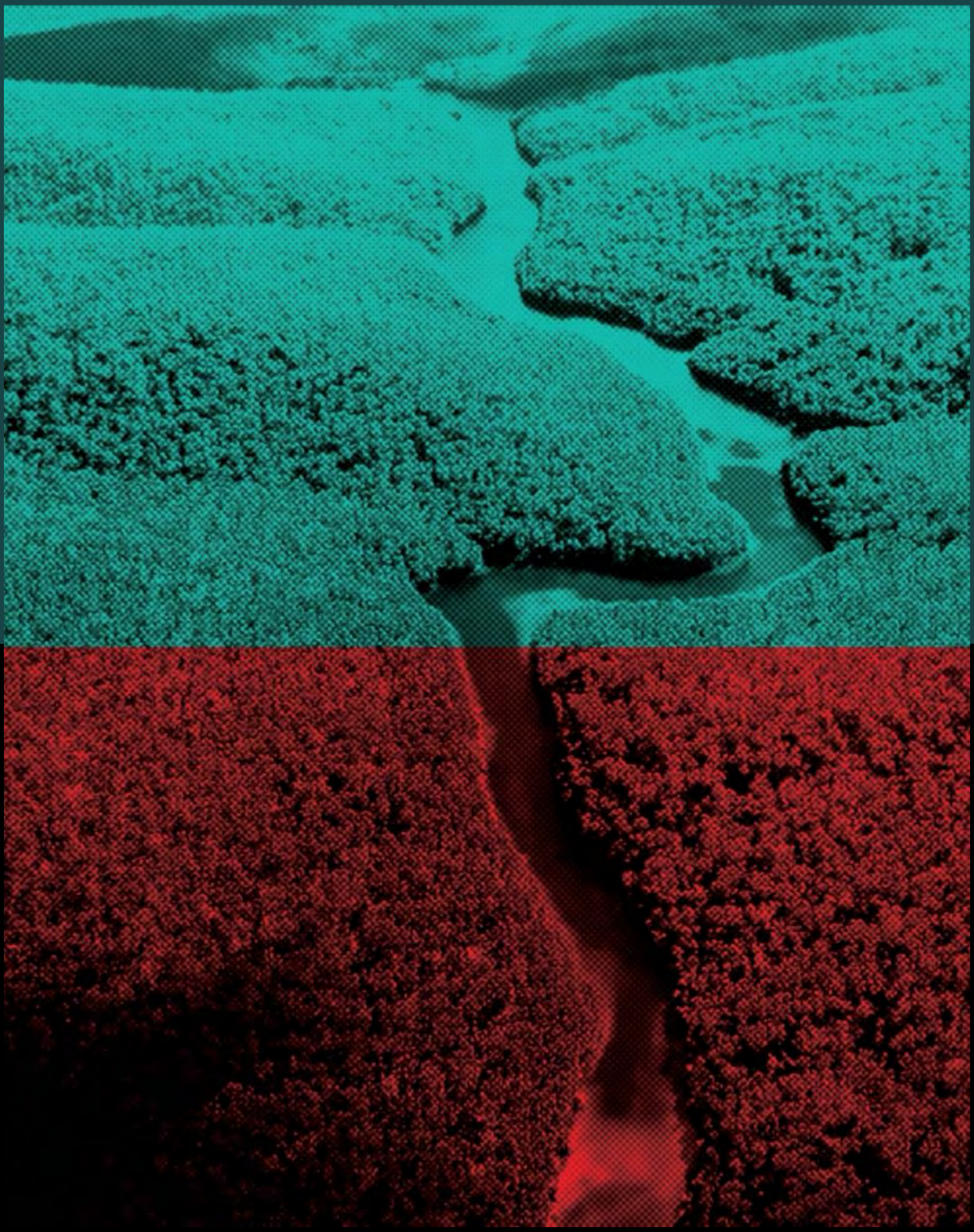
Science Panel for the Amazon

Amazon Assessment Report 2021

PART III



THE AMAZON WE WANT

Science Panel for the Amazon

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK

A GLOBAL INITIATIVE FOR THE UNITED NATIONS

About the Science Panel for the Amazon (SPA)

The Science Panel for the Amazon is an unprecedented initiative convened under the auspices of the United Nations Sustainable Development Solutions Network (SDSN). The SPA is composed of over 200 preeminent scientists and researchers from the eight Amazonian countries, French Guiana, and global partners. These experts came together to debate, analyze, and assemble the accumulated knowledge of the scientific community, Indigenous peoples, and other stakeholders that live and work in the Amazon.

The Panel is inspired by the Leticia Pact for the Amazon. This is a first-of-its-kind Report which provides a comprehensive, objective, open, transparent, systematic, and rigorous scientific assessment of the state of the Amazon's ecosystems, current trends, and their implications for the long-term well-being of the region, as well as opportunities and policy relevant options for conservation and sustainable development.

 ISBN: 9781734808001

Suggested Citation (Full Report)

Science Panel for the Amazon. 2021. Amazon Assessment Report 2021. Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/RWSX6527

Suggested Citation (Individual Chapters)

Chapter 25
Alencar A, Painter L, Athayde S, Bynoe P, Duchelle AE, Hecht S, Murmis MR, Paez B, Soltani A, Lucas IL. 2021. Chapter 25: A Pan-Amazonian Sustainable Development Vision. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/IBHC5215

Chapter 26
Painter L, Alencar A, Bennett A, Bynoe P, Guio C, Murmis MR, Paez B, Robison D, von Hildebrand M, Ochoa-Herrera V, Lucas IL. 2021. Chapter 26: Sustainable Development Goals (SDGs) and the Amazon. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/PGPN1316

Chapter 27
Barlow J, Lees AL, Sist P, Almeida R, Arantes C, Armenteras D, Berenguer E, Caron P, Cuesta F, Doria C, Ferreira J, Flecker A, Heilpern S, Kalamandeen M, Nascimento N, Peña-Claros M, Piponiot C, Pompeu PS, Souza C, Valentin JF. 2021. Chapter 27: Conservation measures to counter the main threats to Amazonian biodiversity. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/DTTQ9410

Chapter 28
Barlow J, Sist P, Almeida R, Arantes C, Berenguer E, Caron P, Cuesta F, Doria C, Ferreira J, Flecker A, Heilpern S, Kalamandeen M, Lees AL, Nascimento N, Peña-Claros M, Piponiot C, Pompeu PS, Souza C, Valentin JF. 2021. Chapter 28: Restoration Options for the Amazon. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/OSPD2912

Chapter 29
Barlow J, Sist P, Almeida R, Arantes C, Berenguer E, Caron P, Cuesta F, Doria C, Ferreira J, Flecker A, Heilpern S, Kalamandeen M, Lees AL, Nascimento N, Peña-Claros M, Piponiot C, Pompeu PS, Souza C, Valentin JF. 2021. Chapter 29: Restoration Priorities and Benefits within Landscapes and Catchments and Across the Amazon Basin. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/GGIR9016

Chapter 30
Abramovay R, Ferreira J, Costa FA, Ehrlich M, Euler AMC, Young CEF, Kaimowitz D, Moutinho P, Nobre I, Rogez H, Roxo E, Schor T, Villanova L. 2021. Chapter 30: The New Bioeconomy in the Amazon: Opportunities and Challenges for a Healthy Standing Forest and Flowing Rivers. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G,

Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/UGHK1968

Chapter 31

Barretto Filho HT, Ramos A, Barra AS, Barroso M, Caron P, Benzi Grupioni LD, von Hildebrand M, Jarrett C, Pereira Junior D, Painter L, Pereira HS, Rodríguez Garavito C. 2021. Chapter 31: Strengthening Governance and Management of Lands and Natural Resources: Protected Areas, Indigenous Lands, and Local Communities' Territories. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/NQBA9165

Chapter 32

Frieri S, Bortolotto F, Rivera GA, Baniwa A, Herrera B, Van der Hammen C, Moutinho P, Arieira J. 2021. Chapter 32: Milestones and challenges in the construction and expansion of a participatory inter-cultural education in the Amazon. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA.
Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/QKZE7803

Chapter 33

Varese M, Rodríguez Garavito C, Piland N, Athayde S, Alvira Reyes D, Doria C, Echeverri JA, Jarrett C, Matapí U, Brito Maciel NJ, Posada V, Román-Jitdutjaaño OR, Tello L, Trujillo LA. 2021. Chapter 33: Connecting and Sharing Diverse Knowledge towards Sustainable Pathways in the Amazon. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/DYAK8997

Chapter 34

Lapola DM, Páez B, Costa S, Silva Júnior RD, Peluso D, Moutinho P, Nascimento N, Padgurschi MCG, Baniwa D, Bridi S, Calapucha N, Castro Z, Falconí F, Junior J, Kamayurá, Kohn E, Mattos A, Nassar PM, Troost L, Ushigua M, Wallace R, Zangas M. 2021. Chapter 34: Boosting the relations between the Amazon forest and globalizing cities. In: Nobre C, Encalada A, Anderson E, Roca Alcazar FH, Bustamante M, Mena C, Peña-Claros M, Poveda G, Rodriguez JP, Saleska S, Trumbore S, Val AL, Villa Nova L, Abramovay R, Alencar A, Rodríguez Alzza C, Armenteras D, Artaxo P, Athayde S, Barretto Filho HT, Barlow J, Berenguer E, Bortolotto F, Costa FA, Costa MH, Cuvi N, Fearnside PM, Ferreira J, Flores BM, Frieri S, Gatti LV, Guayasamin JM, Hecht S, Hirota M, Hoorn C, Josse C, Lapola DM, Larrea C, Larrea-Alcazar DM, Lehm Ardaya Z, Malhi Y, Marengo JA, Melack J, Moraes R M, Moutinho P, Murmis MR, Neves EG, Paez B, Painter L, Ramos A, Rosero-Peña MC, Schmink M, Sist P, ter Steege H, Val P, van der Voort H, Varese M, Zapata-Ríos G (Eds). Amazon Assessment Report 2021. United Nations Sustainable Development Solutions Network, New York, USA. Available from https://www.theamazonwewant.org/spa-reports/. DOI: 10.55161/GBHP6876

Part III

The Solution Space: Finding Sustainable Pathways for the Amazon

Table of Contents

Chapter 25: A Pan-Amazonian sustainable development vision

Chapter 26: Sustainable Development Goals (SDGs) and the Amazon

Chapter 27: Conservation measures to counter the main threats to Amazonian biodiversity

Chapter 28: Restoration options for the Amazon

Chapter 29: Restoration priorities and benefits within landscapes and catchments and across the Amazon basin

Chapter 30: Opportunities and challenges for a healthy standing forest and flowing rivers bioeconomy in the Amazon

Chapter 31: Strengthening land and natural resource governance and management: Protected areas, Indigenous lands, and local communities' territories

Cross-Chapter Box: Legacy from the Ancestors: Amazonian Biocultural Landscapes and Global Sustainability in a Post-COVID-19 World

Chapter 32: Milestones and challenges in the construction and expansion of participatory intercultural education in the Amazon

Chapter 33: Connecting and sharing diverse knowledges to support sustainable pathways in the Amazon

Chapter 34: Boosting relations between the Amazon forest and its globalizing cities

FOREWORD

The Amazon Assessment Report is a marvel of scientific accomplishment and collaboration. Most of all, it is a result of the profound dedication of more than 200 scientists from the Amazon Basin nations to the well-being of the peoples and biodiversity of this unique part of the world. The Amazon merits every superlative thrown its way: unique, irreplaceable, mega-diverse, invaluable, and gravely endangered. The Science Panel for the Amazon has not only provided us with the most comprehensive and compelling scientific portrait of the Amazon ever produced, but has also provided a roadmap to the Amazon's survival and thriving. They show us, in short, the pathway to the Amazon We Want.

My colleague Emma Torres and I, and our fellow members of the UN Sustainable Development Solutions Network (SDSN), are deeply grateful and indebted to the scientist-authors of this volume for the profound care, scientific knowledge, and dedication that they put into this remarkable volume. When Emma and I helped to launch the Science Panel for the Amazon more than a year ago, in the midst of the COVID-19 pandemic, we envisioned that the region's leading scientists would produce a policy report to set guidelines for the Amazon's sustainable development. The scientists of course produced that, but they also produced something vastly greater. They delivered a *magnum opus*, a compelling narrative that begins with the ancient and formative geology of the Amazon Basin and that brings us to the present day, with powerful policy proposals for a new Amazon bioeconomy based on a Living Amazon Vision that "aims to transform the 'life-blind' economic system into one that is 'life-centric.'

Along the way they include a dazzling array of topics to ensure a comprehensive treatment of the Amazon from every major perspective, including the Amazon as a "regional entity of the Earth System," the "anthropogenic changes in the Amazon" including deforestation, and the "solution space" of sustainable pathways for the Amazon Basin. The solutions include bioeconomy strategies, protection of Indigenous lands, restoration of degraded lands, and stronger sustainable relations between the Amazon forest and Amazonian cities.

Both the urgency and timeliness of the report must be emphasized. The urgency is apparent from the core scientific message of the study: the Amazon's ecosystems are not only invaluable but are also gravely imperiled. Because of past deforestation and land degradation, the Amazon may well be close to a tipping point in which major ecosystems of the Amazon would irreversibly collapse or be persistently degraded.

The timeliness results from the fact that the world's nations are finally recognizing the imminent dangers facing the Amazon and the tropical rainforest regions of Africa and Asia. At COP26, more than 130 national governments signed on to a Glasgow Leaders' Declaration on Forests and Land Use, in which they promise to "halt and reverse forest loss and land degradation by 2030." At the same time, public and private sources together pledged more than $10 billion for this cause, with yet more funding to be mobilized. These governments have recognized, finally, that there can be no solution to climate change without ending deforestation and restoring degraded lands, in conjunction with transforming the global energy system to zero-carbon energy sources.

Even as the Assessment Report is being launched, the transformative importance of the Science Panel for the Amazon is already being recognized by governments in the region and by key international development agencies and institutions. This report and the ongoing work of the SPA will be taken up by the Leticia Pact that brings the region's leaders together to protect the common heritage of the Amazon, and by the

Amazon Cooperation Treaty Organization. Also, leading scientists working in other critical ecosystems, including the Congo Basin and the tropical forests of southeast Asia, are looking to the SPA for inspiration and guidance on how to carry out similar scientific collaborations and initiatives in those ecosystems as well.

Let us therefore savor the remarkable scientific insights gathered in this study, and commit as well to act upon the urgent messages of the SPA. If we act decisively and cooperatively, with the Amazon Basin countries cooperating closely and the rest of the world joining in urgent support of the Amazon, we can achieve the SPA's vision of "a healthy, standing forest and flowing rivers bioeconomy based on exchange and collaboration between local and Indigenous knowledge, science, technology, and innovation."

Jeffrey Sachs
SPA Convener

ACKNOWLEDGEMENTS

We would like to express our profound gratitude to the many people and institutions that made this Report possible.

We are indebted to the more than 200 experts who generously contributed their time and knowledge to this Report, as members of the Science Steering Committee, lead authors, chapter lead authors, and contributing authors. We are fortunate to have had the opportunity to work with so many passionate, brilliant, engaged, and collegial individuals and research teams.

We are profoundly grateful to the SPA Strategic Committee. Your distinguished leadership has been most valuable in providing strategic guidance to the work of the panel.

We are grateful to the members of the Technical Secretariat. This Assessment would not have been possible without their diligent efforts and dedication.

We also wish to express our profound gratitude to the peer reviewers who helped improve and clarify the Report, and to the many stakeholders who provided invaluable input through the public consultation as well as by other means.

The Science Panel for the Amazon (SPA) would like to acknowledge the generous financial support provided by our partners, the Gordon and Betty Moore Foundation and the Charles Stewart Mott Foundation.

We are also grateful for contributions from the Bobolink Foundation, the French Government through a grant by Conservation International (CI), The Field Museum, the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), the Interamerican Development Bank (IDB), and the World Wide Fund for Nature (WWF-Brazil). The opinions, findings, and conclusions stated in this Report are those of the author(s) and do not necessarily reflect those of our partners and sponsors.

We are sincerely grateful to a number of other individuals and institutions for supporting this report with research, data, expertise, advice, services, and grants.

In gratitude,

Jeffrey Sachs	Emma Torres	Carlos Nobre	Andrea Encalada
Convener	Strategic Coordinator	Co-Chair	Co-Chair

Strategic Committee: Gastón Acurio, Avecita Chicchon, Luiz Davidovich, Jose Gregorio Díaz Mirabal, Gustavo Dudamel, Maria Fernanda Espinoza Garcés, Enrique Forero, Valerie Garrido-Lowe, Angel Guevara, Marina Helou, André Lara Resende, Guilherme Leal, Thomas Lovejoy, Luis Moreno, Beka Munduruku, Rubens Ricupero, Fernando Roca, Sebastião Salgado, Monsignor Marcelo Sánchez Sorondo, President Juan Manuel Santos, Achim Steiner, Christiane Torloni, and Clarence Seedorf

Science Steering Committee: Elizabeth Anderson, Fernando Hector Roca Alcazar, Mercedes Bustamante, Carlos Mena, Marielos Peña-Claros, German Poveda, Jon Paul Rodriguez, Scott Saleska, Susan Trumbore, Adalberto Val, Luciana Villa Nova

Lead Authors: Ricardo Abramovay, Ane Alencar, Ana Carolina R. Alzza, Dolors Armenteras, Paulo Artaxo, Simone Athayde, Henyo Trindade Barretto Filho, Jos Barlow, Erika Berenguer, Fernanda Bortolotto, Francisco de Assis Costa, Marcos Heil Costa, Nicolás Cuvi, Philip M. Fearnside, Joice Ferreira, Bernardo M. Flores, Sandra Frieri, Luciana V. Gatti, Juan M, Guayasamin, Susanna Hecht, Marina Hirota, Carina Hoorn, Carmen Josse, David M. Lapola, Carlos Larrea, Daniel M. Larrea-Alcazar, Zulema Lehm Ardaya, Yadvinder Malhi, José A. Marengo, John Melack, Mónica Moraes R., Paulo Moutinho, María R. Murmis, Eduardo G. Neves, Belen Paez, Lilian Painter, Adriana Ramos, Martha Cecilia Rosero-Peña, Marianne Schmink, Plinio Sist, Hans ter Steege, Pedro Val, Hein van der Voort, Mariana Varese, and Galo Zapata-Ríos

Contributing Authors: Rebecca Abers, Ana Paula Aguiar, James S. Albert, Claudio Almeida, Rafael Almeida, Vera Maria F. Almeida-Val, Angelica Almeyda-Zambrano, Lincoln Muniz Alves, Cecilia S. Andreazzi, Luiz E.O. Aragão, Caroline Arantes, Alessandro C.de Araujo, Julia Arieira, Eduardo D. Assad, Tasso Azevedo, André Baniwa, Daniel Baniwa, Camila Sobral Barra, Marivelton Barroso, Luana S. Basso, Denise Humphreys Bebbington, Aoife Bennett, Carla Jaimes Betancourt, Richard A. Betts, Bibiana Alejandra Bilbao, Laura S. Borma, Paulo M. Brando, Sonia Bridi, Eduardo Brondizio, Paulette Bynoe, Nadino Calapucha, Derek Campos, João Paulo Ribeiro Capobianco, Thiago Cardoso, Ana Carolina Carnaval, Patrick Caron, Juan D. Carrillo, Zienhe Castro, Michael T. Coe, Sandra B. Correa, Sandra Costa, Mily Crevels, Francisco Cuesta, Liliana M. Davalos, Luisa Esther Diaz Arriola, Luis Donisete Benzi Grupioni, Carolina Rodrigues da Costa Doria, Amy E. Duchelle, Fabrice Duponchelle, Ana Margarida Duran Calisto, Juan Alvaro Echeverry, Marco Ehrlich, Andrés Escobar, Jhan-Carlo Espinoza, Adriane Esquivel-Muelbert, Ana Euler, Doris Fagua Rincon, Fander Falconí, Jorge Figueiredo, Matthew Finer, Suzette G.A. Flantua, Alexander Flecker, Carlos Eduardo Frickmann Young, Rong Fu, Laura P. Furquim, Silvia de Melo Futada, César Rodriguez Garavito, Roosevelt García-Villacorta, Rachael Garrett, Camilo Guio, Sandra Hacon, Sebastian Heilpern, Bernardo Herrera, Catarina C. Jakovac, Christopher Jarret, Clinton N. Jenkins, Juan-Carlos Jimenez Muñoz, James Junior, André B. Junqueira, David Kaimowitz, Michelle Kalamandeen, Mapulu Kamayurá, Jürgen Kesselmeier, Eduardo Kohn, Alexander C. Lees, Isabella Leite, Andrés (Willy) Lescano, Carolina Levis, Lúcia G. Lohmann, Marcia Macedo, Carla Maldonado, Luz Marina Mantilla, Jose Daniel M. Marra, Carlos (Uldarico) Matapí, Anderson Mattos, David McGrath, Gustavo Henrique Coelho Melo, Diego Meneghelli, Fernando Miralles-Wilhelm, Guido Miranda, Anna G. Mombiola, Encarni Montoya, Mariana Montoya, Edel Moraes Tenório, Claide P. Moraes, Gaspar Morcote-Ríos, María de los Ríos Almandoz Moreno, Federico Mosquera Guerra, Nathália Nascimento, Pedro Meloni Nassar, Ismael Nobre, Felipe Nunes, Valeria Ochoa-Herrera, Gustavo Oliveira, Maria A. (Tina) Oliveira-Miranda, Rafael S. Oliveira, Jean Pierre Ometto, Fernando Ozorio de Almeida, German Palacio, Sunitha R. Pangala, Daniela Peluso, Henrique dos Santos Pereira, Davi Pereira Junior, Stefan Peters, Oliver L. Phillips, Eduardo Pichilingue, Natalia Piland, Miguel Pinedo-Vasquez, Camille Piponiot, Paulo dos Santos Pompeu, Visnu Posada, Carlos Alberto Quesada, Raoni Rajão, Ying Fan Reinfelder, Natalia Restrepo-Coupe, Diana Alvira Reyes, Camila C. Ribas, Humberto Ribeiro da Rocha, Douglas Riff, Gloria Amparo Rivera, Luciana Rizzo, Daniel Robison, Bruna C. Rocha, Carlos Rodriguez, Herve Rogez, Oscar

R. Román-Jitdutjaaño, Eduardo Roxo, Boris Sakschewski, Norma Salinas, Jochen Schöngart, Tatiana Schor, Glenn Shepard, Myrtle P. Shock, Miles Silman, Celso H. L. Silva Junior, Roberto Donato da Silva Júnior, Maria Aurea Pinheiro de Almeida Silveira, Divino V. Silvério, Charlotte Smith, Britaldo Soares-Filho, Atossa Soltani, Carlos Souza, Gasodá Wawaeitxapôh Surui, Tod D. Swanson, Gabriella Tabet, Eduardo K. Tamanaha, Leonardo Tello, Emiliano Terán, Laurent Troost, Fernando Trujillo, Luis Angel Trujillo, Ermeto Tuesta, Carmen Ulloa Ulloa, Manari Ushigua, Judson F. Valentim, Clara van der Hammen, Richard van der Hoff, Silvia Vidal, Martin von Hildebrand, Robert B. Wallace, Jennifer G. Watling, Stefan Wolff, Markos Zangas-Tsakiris, and Stanford Rhode Zent

Peer Reviewers: Cristina Adams, Orangel Aguilera, Sonia Alfaia, Silvana Amaral, Tercio Ambrizzi, Manuel Arroyo-Kalin, William Balée, Tim Baker, John Blake, Jan Börner, Pedro Brancalion, Carlos Zárate Botía, Ana Carla Bruno, Peter Bunyard, Carla Cárdenas, Raquel Carvalho, Alessandro Catenazzi, Josefa Salete Barbosa Cavalcanti, Mariano Cenamo, Robin Chazdon, Renan Campos Chisté, Charles Clement, Roberto Dall'Agnol, Eric Davidson, Pedro Leite da Silva Dias, Han Dolman, Marc J. Dourojeanni, Juan Alvaro Echeverri, Gilberto Fisch, Toby Gardner, Cécile Gautheron, Cullen Hanks , Michael Heckenberger, Alfredo Kingo Oyama Homma, Richard Houghton, Carlos Jaramillo, Ora Johannsson, Pilar García Jordán, Andrea Lampis, Marcos Longo, Viviana Lopez-Hernandez, William Magnusson, Francesca Majorano, Stephanie Mansourian, Jacques Marcovitch, John Miller, Patricia Morellato, Robinson I. Negrón-Juárez, Guillermo Obregon, Guilherme Oliveira, Enrique Ortiz, Michael Painter, Rene Parra, John Parrota, Toby Pennington, Stephen Perz, Oliver L. Phillips, Maitê Piedade, Roberto Porro, Peter Poschen, Anja Rammig, Carly Reddington, Laura Rival, J. Timmons Roberts, Stéphen Rostain, Rosa Lemos de Sá, Andre Sawakuchi, Fabio Scarano, Roberto Shaeffer, Jose Maria Cardoso da Silva, Paulo Sobral, Gustavo Solis, Esteban Suarez, Hans ter Steege, Stella de la Torre, Hanna Tuomisto, Ruud J. van der Ent, Celso von Randow, Eduardo Viola, Vincent Vos, Robert Toovey Walker, Robert Wallace, Fernanda Werneck, Ellen Wohl and Xavier Zapata

Public Consultation Contributions: Cassio Bernardino (WWF Brazil), Paula Bueno (WWF Colombia), Joaquin Carrizosa (WWF Colombia), Joao Paulo de Soares Cortes (UFOPA), Brian Crnobrna (RedCons-Ucayali), Carlos de la Torre (University of Florida), Filipe Machado França (Lancaster University), Clarissa Gandour (Climate Policy Initiative and PUC-Rio), Deborah Goldemberg (WWF Brazil), James Gordon (WWF United Kingdom), Tarsicio Granizo (WWF Ecuador), Pia Escobar Gutiérrez (WWF Colombia), Consuelo Hernandéz (Fundación Humedales), Gerbrand Koren (Wageningen University), Claudia Leal León (Universidad de las Andes), Juan Carlos Ledezma (Conservation International), Bette Loisette (University of Florida), Bruno Garcia Luize (Unicamp), Anastassia Makarieva (Petersburg Nuclear Physics Institute), Stephanie Mansourian (University of Geneva), Dean Muruven (WWF International), Luis German Naranjo (WWF Colombia), Miguel Pacheco (WWF Peru), Sandra Petrone (WWF Mexico), Nigel Pitman (Field Museum of Natural History), Silvya Benitez Ponce (The Nature Conservancy), Thomas Ratican (University of Florida), María Inés Rivadeneira (WWF Ecuador), Carlos Rodríguez (Tropenbos Colombia), Jordi Surkin (WWF Bolivia), TR (Tinde) van Andel (Wageningen University), Michiel van den Bergh (WWF Suriname), Analiz Vergara (WWF), Hermani Vieira (EPE), Daphne Willems (WWF International), Mark Wright (WWF United Kingdom)

Interviews: Kleber Abreu, Dirceu Barbano, Andreia Bavaresco, Nurit Bensusan, Marcello Brito, Antônio Britto, Thaís de Carvalho, Mariano Cenamo, Claudia Galvez Durand, Kleber Franchini, Ruth Salzar Gascon, Deborah Goldemberg, André Guimarães, Jorge Hoezl, Kate Horner, Camilo Jaramillo Hurtado, Simão Jatene, Carlos Koury, Fany Kuiru, Riikka Kaukonen Lindholm, Pablo Lloret, Mauricio López, Lars Lovold, Elcio (Toya) Manchineri, Carlos Eduardo Marinelli, Elio "Wayu" Matapi, João Meirelles, Antônio Mesquita, Denis Minev,

Paola Minoia, Berta Lina Murillo, Jhusely Danesy Navarro Patiño, Carina Pimenta, Marcos da Ré, Carlos Rezende, Jaír Rincón, Jaime Siqueira, Roberto Smeraldi, Bruna Stein, Izabella Teixeira, Eduardo Trigo, Daniela Trivella, Sineia Bezerra do Vale, Tuija Veintie, Roberto Waack, Luke Weiss

Technical-Scientific Secretariat: Melanie Argimon, Julia Arieira, Lauren Barredo, Giovanni Bruna, Paulo de Souza, Carolina Jaramillo, Isabella Leite Lucas, Kamsha Maharaj, Nathália Nascimento, Eraclito Neto, Camila Posada, Jessica Tomé, and Catherine Williams.

Communication Senior Advisors: Pilar Calderon, Coimbra Sirica, Ilona Szabo

Photographs: Amazônia Real and their talented contributors, on Flikr as Agência Amazônia Real; IBAMA; the Museu Paraense Emilio Goeldo; WWF, on Shutterstock as Wwf images; and numerous independent photographers and photojournalists.

Maps: Instituto Socioambiental**,** Cicero Augusto**,** Clayton Bittencourt**,** Alicia Rolla

Design: Lanatta Branding and Design

Additional Contributors: Kate Halladay, Charo Lanao, Robert Muggah, Andrew Revkin, and Sly Wongchuig

Partners

ACADEMIA BRASILEIRA DE CIÊNCIAS MCMXVI

CHARLES STEWART MOTT FOUNDATION

GORDON AND BETTY MOORE FOUNDATION

INTRODUCTION

The Amazon Basin holds the most extensive rainforest in the world (~5.8 million km^2), and the largest river, which flows four thousand kilometers from the Andes to meet the Atlantic, carrying more water than any other river (~220,000 m^3/s). Billions of years of geologic and climatic changes and millions of years of biological evolution resulted in a highly heterogeneous region sheltering an unparalleled, vast, but still mostly unknown biodiversity. The Amazon rainforest is a vital ecosystem for the entire planet and part of the irreplaceable heritage for all humanity. The Amazon Basin is also home to Indigenous peoples that co-evolved with biodiverse ecosystems for more than ten thousand years, driving the emergence of a vast biocultural diversity.

Notwithstanding, the Amazon and its inhabitants have been historically threatened by a resource-based development model with a monetary-centric vision that causes ecosystem destruction while maintaining inequalities and violence. This model has been associated with a tremendous loss of intact, diverse forests and degradation of terrestrial and aquatic ecosystems by deforestation, non-natural fires, logging, natural resources exploitation, and pollution. Together with global climate change, these activities are pushing the Amazon towards a tipping point beyond which lies irreversible loss of the rainforest and its biodiversity, severely compromising human well-being. Halting deforestation and ecosystem degradation and finding alternative pathways towards the sustainable development for the Amazon are a priority under this critical scenario.

Despite the existing wealth of scientific and socio-environmental knowledge on the Amazon, there are still significant gaps in our understanding; this affects our ability to guide conservation strategies and support science-based decision-making processes, and demands great scientific and technological efforts to overcome. For instance, although scientists have described thousands of species in the Amazon, the full dimensions of Amazonian biodiversity remain vastly underestimated. Furthermore, despite the great effort of scientists to quantify carbon emissions and ecosystem productivity, limited data on the potential effects of CO_2 fertilization on photosynthesis and water use by trees restrict our understanding of forest resilience in the face of climate change. Finally, notwithstanding the enormous diversity of knowledge systems connected to the Amazon´s cultural and biological diversity, there are limited investigations into how these systems generate, transmit, and use such knowledge.

Under the auspices of the UN Sustainable Development Solutions Network (SDSN), over 200 scientists from the Amazon and who study the Amazon have come together to form the unprecedented Science Panel for the Amazon (SPA). They brought together their knowledge and experience to produce a Scientific Assessment of the state of the diverse ecosystems, land uses, and environmental changes in the Amazon and their implications for the region and other parts of the world. The challenge was unprecedented, to produce the first full-fledged scientific report carried out for the entire Amazon Basin and its various biomes, including an opportunity to develop a new, sustainable paradigm that ensures that the forest is worth far more standing than cut down, and that freshwater resources are managed sustainably. The well-being of those who inhabit the planet today and of generations to come depends on conservation of the Amazon.

This Report is divided into three main parts, each containing four Working Groups and together totaling 34 chapters:

I - The Amazon as a Regional Entity of the Earth System
II - Social-Ecological Transformations: Changes in the Amazon
III - The Solution Space: Finding Sustainable Pathways for the Amazon

Part I addresses an undisturbed - or with very low human-induced disturbance –Amazon Basin through the geologic, climatic, and ecological evolution of terrestrial and aquatic ecosystems and biodiversity. It explores why the Amazon rainforest is an important contributor to regional and global biogeochemical cycles, such as the carbon cycle and major nutrient cycles, and synthesizes the main mechanisms which operate in the physical hydroclimate of the Amazon. Part I ends by exploring human presence in the Amazon, highlighting the critical role of Indigenous peoples and local communities (IPLCs) in the sustainable use and conservation of Amazonian biodiversity and the consequences of European colonization for these populations.

Part II focuses on increasing anthropogenic changes in the Amazon, mainly from the 1960s to the present day. From the 1960s onwards, the Amazon experienced the most profound socio-environmental transformation in its history. Part II starts by reviewing the current situation of the diverse peoples who live, move, and work in the Amazon region, putting into context the changes in global policies and deep regional integration into the world economy. Such integration moved the Amazon to the top tiers in global exports of beef, iron, gold, timber, cocoa, and soy, which occurred in the context of highly unequal societies, threatening the rainforest, aquatic ecosystems, and the survival of IPLCs. National conservation policies are discussed as a counterforce to protect biodiversity, cultural diversity, and the territorial rights of IPLCs. Next, the chapters analyze the current reality of a highly complex and dynamic mix of rural and urban activities, including the formal, informal, and clandestine economies that drive deforestation. This includes the expansion of pastures and croplands, and ecosystem degradation such as pollution and forest fires. The cumulative impacts of multiple drivers of forest loss and terrestrial and aquatic degradation on biodiversity, climate, and the carbon cycle are described from the local to the global perspective, including their cascading effects on agriculture, hydropower generation, and human health and well-being. Last but not least, Part II ends with a warning of the imminent risk of crossing a tipping point due to ongoing land conversion and climate change; beyond this point, continuous forests can no longer exist and are replaced by highly degraded ecosystems.

Part III of the report focuses on solutions, presenting recommendations based on scientific and traditional knowledge, guided by the principles and values of the *Living Amazon* vision. This vision proposes a sustainable development model for the Amazon that is socially just, inclusive, and ecologically and economically flourishing. It recognizes the role of the Amazon in the 21st Century and the need for economies that can sustain ecological integrity and diversity, protect terrestrial and aquatic ecosystems, restore and remediate impacted ecosystems, empower Amazonian people, protect human rights and the rights of nature, and promote human-nature well-being. The solutions proposed are based on three pillars:

1) Conservation, restoration, and remediation of terrestrial and aquatic systems
2) Development of an innovative, healthy, standing forests, flowing rivers bioeconomy; addressing policies and institutional frameworks for human-environmental well-being and biodiversity protection; ingenuously combining the knowledge of IPLCs and scientific knowledge; and investing in research, marketing, and production of Amazonian socio-biodiversity products
3) Strengthening Amazonian citizenship and governance, which includes the implementation of bio-regional and bio-diplomatic governance systems (environmental diplomacy) to promote better management of natural resources and strengthen human and territorial rights

More than ever, the SPA Assessment is a timely opportunity to show the connection between human well-being and nature to a broad audience, including decision makers. The sustainable functioning of the Amazon's ecosystems guarantees the safety of the people who live in the Amazon and its surroundings, and supports planetary health. The SPA Report urges decision makers and all societies to act now to prevent further devastation in the region. Key outcomes of this unprecedented scientific report are new recommendations for a sustainable Amazon, which can serve as models for all tropical forests. Given the rapid transitions experienced by the Amazon and the world, there is great need for better communication between policy makers and the scientific community, including consensus on several key issues. Although threats and their administration fall first and foremost to Amazonian nations, the responsibility of saving the Amazon is global. What transpires in the Amazon in one country affects the Amazon in all countries, and what happens in the Amazon affects the entire world. Therefore, actions within the Amazon itself convergent with global actions to stop human-induced Amazon crises are urgent.

Carlos Nobre	Mercedes Bustamante
SPA Co-Chair	*SPA Science Steering Committee*

Chapter 25

A Pan-Amazonian sustainable development vision

Vida cotidiana no lado Atroari da Vila de Balbina (Foto: Bruno Kelly/Amazônia Real)

INDEX

GRAPHICAL ABSTRACT **3**

KEY MESSAGES **4**

ABSTRACT **4**

25.1 INTRODUCTION **5**

25.2 CONTEXT FOR THE LIVING AMAZON VISION **6**

25.2.1 The Amazon today 6
25.2.2 Historical worldviews and emerging alternative frameworks for a Living Amazon 8
25.2.3 The plurality of social actors, interests, and perspectives in the Amazon 10
25.2.4 The regional and global vision for the Amazon 11
25.2.5 Experiences of sustainable development in Amazonian countries 13

25.3 PRINCIPLES AND VALUES FOR A LIVING AMAZON **16**

25.3.1 The Amazon is the world's largest tropical rainforest and largest river by volume with a unique geodiversity, exceptional biodiversity, and high level of endemism, which must be valued, respected, and protected 16
25.3.2 The Amazon provides key, cross-scale regulatory ecosystem functions, especially for climate, hydrology, and biodiversity that form the basis of water and food security 16
25.3.3 Use of the Amazon's natural resources must support ecological processes, functions, and livelihoods in the face of a climate crisis and a potential tipping point 16
25.3.4 Urban and rural areas of the Amazon must function as integrated productive systems that promote and support a wide range of socio-economic and ecological benefits 18
25.3.5 Amazonian governance must include participatory processes of engagement among diverse stakeholders and across scales for the well-being of the whole 18
25.3.6 The Amazon houses diverse experiential knowledge systems and cultures resulting from the interconnection between people and nature, which must be valued, recognized, and protected 18
25.3.7 Recognition of the rights of Indigenous peoples and local communities and ensuring their access to justice is paramount to promoting well-being for all 19

25.4 PILLARS OF THE LIVING AMAZON **20**

25.4.1 Measures to conserve, restore, and remediate terrestrial and aquatic systems 20
25.4.1.1 Expand, consolidate, and secure protected areas 20
25.4.1.2 Cease deforestation, degradation, and contamination of terrestrial and aquatic ecosystems 21
25.4.1.3 Restore and remediate landscapes and watersheds for maximizing multiple ecosystem services 21
25.4.1.4 Implement systems to monitor, evaluate, and hold stakeholders accountable for restoration and remediation 21
25.4.1.5 Implement global and regional incentives for conservation, restoration, and remediation 22
25.4.1.6 Signaling Urgency 22
25.4.2 Developing sustainable and circular bioeconomy arrangements for standing forests and flowing rivers 23
25.4.2.1. Invest in the research, marketing, and productivity of Amazonian socio-biodiversity products 23

25.4.2.2 Create fiscal incentives to engage the private sector and multilateral institutions in innovation around Amazon products *23*
25.4.2.3 Promote job creation and capacity building for a bioeconomy adapted to the Amazon context *24*
25.4.2.4 Invest in science, education, and the creation of transdisciplinary hubs and centers of excellence in bioeconomy technology in the Amazon *24*
25.4.2.5 Invest in rural, urban, and periurban infrastructure that enables multiple Amazonian human groups to benefit from bioeconomy activities *24*
25.4.2.6 Promote new rules for a regenerative financial system *25*
25.4.3 STRENGTHENING AMAZONIAN CITIZENSHIP AND GOVERNANCE 25
25.4.3.1 Implement a Bioregional and Biodiplomacy (environmental diplomacy) governance system to promote better natural resource management and strengthen human and territorial rights *25*
25.4.3.2 Promote the recognition of different identities, knowledge systems, and rights *25*
25.4.3.3 Engage and consult IPLCs when planning policies regarding bioeconomy arrangements and the use of territories and natural resources *27*
25.4.3.4. Promote political inclusion and representation of IPLCs in the legislative branch and enhance decision-making capacity in public policy *27*

25.5 CONCLUSIONS **29**

25.6 RECOMMENDATIONS **29**

25.7 REFERENCES **30**

Graphical Abstract

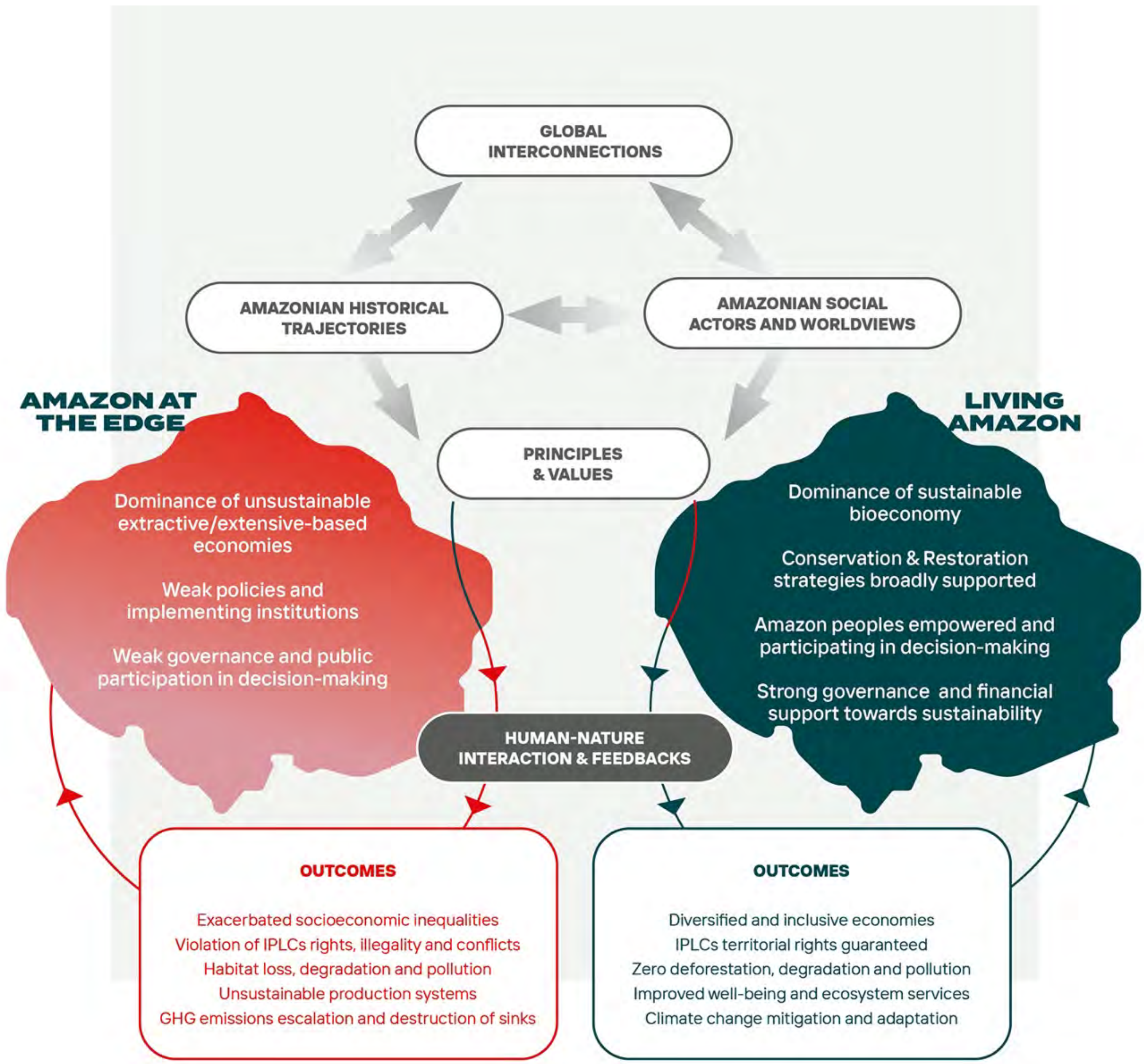


Figure 25.A The global interconnections and the interaction among distinct Amazon worldviews held by the social actors living, governing, and interacting in the Amazon, are based on principles and values that drive human–nature relationships. In the current situation (Amazon at the edge) there are a series of elements in terms of how extensive land use is promoted, governed and how lack of societal participation in decision-making results in outcomes that includes inequalities, violation of human rights, habitat loss, and lack of incentives for sustainable activities. In a Living Amazon, the principles and values that sustain healthy forests, rivers, and peoples are based on a sustainable and circular bioeconomy, conservation strategies, improved governance, and strong public policies. The outcomes of this vision include diversified economies, guaranteed territorial rights to Indigenous peoples and local communities, healthy forests and rivers, and well-being.

A Pan-Amazonian Sustainable Development Vision

Ane Alencar[a], Simone Athayde[b], Paulette Bynoe[c], Amy E. Duchelle[d], Susanna Hecht[e], Maria R. Murmis[f], Belen Paez[g], Lilian Painter[h], Atossa Soltani[i], Isabella Leite Lucas[j]

Key Messages

- Amazonian societies hold multiple and often opposing worldviews about the region's development, making it challenging for them to agree on a shared vision for its future.
- Historic power imbalances have led to the dominance of monetary-centric visions, which have reinforced the false rhetoric that standing forests do not produce socio-economic development and have resulted in socio-economic, race, and gender inequalities, violence, and destruction of the Amazon's ecosystems.
- The Living Amazon Vision presented in this chapter has resulted from consultations with scientists and authors of the Science Panel for the Amazon and is based on a set of guiding principles and values. Building on existing sustainable development policies and approaches, this vision proposes a development model that is socially just and inclusive, as well as ecologically and economically flourishing. It recognizes the role of the Amazon in the 21st Century, and the need for economies that can sustain ecological integrity and diversity, protect human rights and the rights of nature, and promote human-nature well-being.

Abstract

The Amazon holds the highest biodiversity on the planet and is the home to a multitude of peoples, cultures, languages, and lifeways. Its ecosystem services provide fundamental benefits to humans and biodiversity at the local, regional, national, and global scales. As a consequence of this diversity, innumerous worldviews, interests, perspectives, values, and connections exist between Amazonian peoples and ecosystems, biodiversity, and natural resources in the region. However, historical imbalances of power among distinct Amazonian actors and the invisibility of processes at different scales have led to the dominance of certain interests and values over others, and to public policies and institutions that prioritize economic returns from land use, without fully considering the associated environmental, social, and historical costs nor the ecosystems and cultural services benefits. These monetary-centric visions have reinforced the false rhetoric that standing forests do not produce socio-economic development. To break this false paradigm of development *versus* conservation, it is imperative to recognize and integrate these antagonistic visions, address conflicts, and promote recognition of the multiple values of healthy standing forests and free-flowing rivers, as well as cultural interactions with nature and the Amazon as a whole. This chapter proposes a life-centric vision that supports a sustainable Amazon, in which the use of its

[a] Amazon Environmental Research Institute, SCLN 211, Bloco B, Sala 201, Brasília DF 70863-520, Brazil, ane@ipam.org.br
[b] Kimberly Green Latin American and Caribbean Center, Florida International University, Deuxieme Maison 353, Modesto A. Maidique Campus, Miami FL 33199, United States
[c] University of Guyana, Turkeyen Campus, Greater Georgetown, Guyana
[d] Center for International Forestry Research, Situ Gede, Bogor Barat, Bogor 16115, Jawa Barat, Indonesia
[e] University of California, Luskin, 337 Charles E Young Dr E, Los Angeles CA 90095, United States
[f] Universidad Andina Simon Bolivar, Toledo N22-80, Quito, Ecuador
[g] Fundación Pachamama, Vía Lumbisí Km 2, Office 5, Quito 170157, Ecuador
[h] Wildlife Conservation Society, C. Gabino Villanueva Nº 340, Entre 24 y 25 de Calacoto, Casilla: 3 - 35181 SM, Potosí, Bolivia
[i] Amazon Sacred Headwaters Initiative, The Pachamama Alliance P.O. Box 29191 San Francisco CA 94129, United States
[j] Sustainable Development Solutions Network, 475 Riverside Drive, Suite 530, New York NY 10115, United States

resources and biodiversity in the present will not compromise the existence of future generations of human and non-human beings. The Living Amazon Vision results from consultations with scientists and authors of the Science Panel for the Amazon, and their multiple interactions with stakeholders in the region, as well as a dialogue between Indigenous knowledge and science. This vision is based on a set of values, principles, and knowledge systems described throughout the chapter. The strategies to reach a Living Amazon Vision of the future, based on a development model that is inclusive, just, and socially, environmentally, and economically healthy, includes (i) the conservation, sustainable management, restoration, and remediation of ecosystems; (ii) the incentive for developing an inclusive and just bioeconomy; and (iii) the strengthening of governance and people's empowerment, and aligning policies at multiple scales, including transboundary coordination.

Keywords: Sustainability, Amazonian worldviews, bioeconomy, social justice, ecological integrity, environmental protection, Pan-Amazon governance.

25.1 Introduction

Developing a clear vision is a central starting point from which any action plan emanates, creating the foundations to provide meaning, direction, substance, and boundaries. Having a vision is necessary to change course; an action plan could be successfully put into practice if all stakeholders involved agree on a shared vision and participate in its construction. This is a complex task for the Amazon, in which an intricate and diverse network of stakeholders from different countries have interests—often opposing—in the land and its resources.

Assessing these multiple visions and agreeing on a common one is not a simple undertaking. As discussed in this chapter, multiple visions can be embedded in distinct worldviews, which are deeply rooted in sociocultural identities and contexts. They may depend on where you come from (e.g., major capitals, local cities, towns, communities in rural areas); and who you are, what you do, and how you do it (e.g., Indigenous peoples speaking different languages, non-Indigenous local communities, migrants, traditional loggers, ranchers and farmers, modern producers and large mining, oil, agribusiness, or timber enterprises; municipalities, provinces, states and national governments; the military; civil servants and contractors managing infrastructure that serves distant populations; urban populations; and even drug traffickers, smugglers and illegal miners and loggers). The distinct scales and dimensions at which the Amazon is being explored will offer different perspectives: global, national, provincial, local; private, public, civil society; sector or activity; economic, political, social, and natural.

When thinking about a vision, it is of utmost importance to consider the Amazon's diverse populations and remember that this is not an empty space (see Chapters 8–14). This biodiverse, naturally bountiful biome contains the largest rainforest in the world and more than 40 million people (RAISG 2020). If we consider the remote but steadfast economic and political interests that have a significant influence on the Amazon's fate (see Chapters 14 and 17), it would be fair to say that even more people occupy the "space". The Amazon is a central stage in the interconnected world of globalization.

The current path of exploitation that the Amazon is on is leading to its destruction and putting in peril the living world that depends on it, both locally and globally. In order to change course, we must compromise on a vision rooted in values, principles, cultural assumptions, and metrics that drive human institutions and sustain life in all forms. We need to foster a new ethic, a mutually enhancing human–nature relationship at all scales: individuals, communities, watersheds, ecosystems, biomes, and ultimately on a planetary scale. The emerging Living Amazon Vision aims to transform the "life-blind" economic system to one that is "life-centric" and based on values and principles of mutual benefit, in which both people and the Amazon rainforest, including its monumental rivers, can flourish. This framework would recognize the well-being of people and the web of life as inextricably linked. The Living Amazon Vision represents a moonshot goal; an ambitious vision to achieve what may seem inconceivable today. Averting a potential tipping point (see Chapter 24) of the collapse of the Amazon biome's hydro-climatic system will require nothing less. This chapter represents, in many ways, the first steps into the future.

The most important indubitable fact that we must take from this chapter and this work is that an environmentally and socially sustainable, inclusive, and just Amazon, where people and nature thrive, requires that we abandon the unsustainable short-term extractive-based economy vision and model that have dominated the region until now, and that have brought us this far. Stakeholders will need to be willing to compromise and agree on an encompassing vision that accommodates their own. If we collectively accept that, in will and commitment, in thought and on paper, we may be able to overcome our biggest obstacle. The age of COVID-19, with its dire consequences, provides a transparent example of how lifestyle changes are possible when will and commitment accompany thought and proclamation. Similar to what happened during the COVID-19 pandemic, fundamental change can usher in improvements and opportunities in the quality and possibility of life. That is the purpose of the transformational vision proposed below: the vision of a Living Amazon that is ecologically healthy, socially fair, culturally inclusive, and economically viable.

25.2 Context for the Living Amazon Vision

25.2.1 The Amazon today

The Amazon is a vital entity for the planet. The largest tropical forest in the world has evolved over the past millions to billions of years into complex, dynamic, and heterogeneous landscapes that are essential for life on Earth (see Chapters 1–7). Its geodiversity is represented by specific geomorphologies and unique habitats with a high degree of endemism (Sombroek 2000; Alvez-Valles *et al*. 2018; see also Chapters 2 and 3). The result is a diverse mosaic of dominant forests, with encrusted savannas and grasslands, forming one of the most biodiverse and functionally diverse terrestrial and aquatic ecosystems on Earth (see Chapters 1–4; Wittmann *et al*. 2006; Sakschewski *et al*. 2016). Estimated to host 22% of the tropical vascular plant species, the Amazon is home to approximately 14%, 9%, and 8% of tropical birds, mammals, and amphibians, respectively, and to approximately 15% of the world's freshwater fishes (Chapters 2–4; ter Steege *et al*. 2020).

Holding 10% of the planet's biomass and representing 16–20% of freshwater discharge on the planet (Baccini *et al*. 2012; Chapter 4), the Amazon Basin provides fundamental ecosystem services to the region and the Globe. The almost 400 billion trees in the Amazon (13% of world trees) are responsible for pumping and recycling water to the atmosphere and holding carbon, contributing to cloud formation, cooling the earth system, sending heat back to the atmosphere, and supporting primary productivity (see Chapters 4–7) (Hilker *et al*. 2014; ter Steege *et al*. 2016; Ahlström *et al*. 2017). Agricultural production in the South American continent—and beyond—is dependent on the maintenance of the essential water cycle functions that these forests provide. The rainforest regulates local and regional temperatures by intense evapotranspiration, maintaining air temperatures below 30°C (see Chapter 7). This regulatory capacity, associated with the year-round level of solar radiance, keeps the rainforest operating at a near optimum for photosynthesis (approximately 16% of global terrestrial GPP), resulting in a significant annual carbon sink of 0.38 (0.28–0.49 95% C.I.) Pg C year-1 (Beer *et al*. 2010; Brienen *et al*. 2015; see also Chapter 6).

The Amazon is also home to a great diversity of human cultures, worldviews, languages, and lifeways, including hundreds of Indigenous peoples, local communities (i.e., Afro-descendant groups, riverine communities, forest extractivist communities, family farmers), and many other human populations, who have developed interconnection with its fundamental ecosystem functions and biodiversity (see Chapters 10, 12, and 13). The region inhabitants have diversified, multi-sited livelihood strategies between urban and rural areas of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, Venezuela, and the French Guiana territory (see Chapter 14). Diverse Indigenous peoples and local communities (IPLCs), living in both urban and rural areas, depend on the ecosystem services and functions provided by the forest and rivers for food, shelter, income, and well-being, and their livelihoods, culture, and languages or dialects are closely connected to Amazonian ecosystems and biodiversity (Lima *et al.* 2016; Iriarte *et al.* 2020; RAISG 2020) (see Chapters 10, 12 and 13).

Despite the importance of the Amazon, its forests have been lost and degraded at accelerated rates compared with other tropical forests (Turubanova *et al.* 2018), and many of its rivers have been polluted, dammed, or fragmented over the past four decades (Castello *et al.* 2013; Latrubesse *et al.* 2017; see also Chapters 14 and 19-21). 17% of forest loss (MapBiomas 2020) and the 17% of associated forest degradation from logging and forest fires affecting the region (most of it in Brazil—85% of deforestation and 69% of the forest degradation; see MapBiomas 2020; Bullock *et al.* 2020; Chapter 19) have been the products of regional, national, and transnational political decisions, environmental processes, market-oriented forces, and social conflicts resulting from development models that helped to establish the landscape as we know it today (Curtis *et al.* 2018). Unfortunately, the development models that have been dominant across Amazonian countries are based on free-market forces, commodity production or extraction, often for export, accompanied by social inequality, poverty, and criminality (see Chapters 14–18).

Under the current paradigm, the compass heading for our economic and political systems is growth and wealth accumulation at the cost of the environment and general human well-being. Governments aim for 3% per year gross domestic product (GDP) growth, which means that the size of the global economy doubles every 20 years (Jones 2016). This growth accompanies a corresponding growth in materials throughput, including commodities that contribute to increased deforestation of the Amazon Basin (Lin *et al.* 2018). Currently, at 80 billion tons per year, the total materials throughput of the global economy is 60% more than the Earth's carrying capacity (Hickel 2018). By 2050, despite the efficiencies from the movement towards "Green Growth", our total materials throughput is projected to reach between 95 billion and 132 billion tons per year—an overshoot far above safe planetary limits (Global Footprint Network 2018).

Achieving the Sustainable Development Goals (SDGs) by 2030 within the present economic model would require a 12-fold increase in the size of the global economy (Woodward 2015). This would likely further accelerate forest and biodiversity loss and push the Amazon past a tipping point (see Chapter 24), impacting rainfall, increasing droughts, and leading to a potentially irreversible change in the remaining forest structure and rivers. This scenario could not only have regional but also global consequences, impacting global carbon stocks and increasing CO_2 emissions from a more prone-to-burn impoverished forest (Aragão *et al.* 2018). It would also affect biodiversity and the people that live and depend on the Amazon forest and rivers, in both urban and rural areas, including other regions that indirectly depend on Amazon-based rainfall (see also Chapter 23).

The window of opportunity for action is rapidly closing, with possibly catastrophic consequences for future generations and the livability of our shared Earth. Donella Meadows, in her seminal work "Leverage Points: Places to Intervene in a System", describes how in complex systems, the most effective points of intervention are: 1) changing the mindset/paradigm that gave rise to the system, and 2) changing the goals of the system. Although these two points of intervention are often the hardest to implement, they produce the most profound system change, whereby, through self-organization, the system can potentially transform itself towards the new goals while keeping the resilience of structures and processes that are vital for the system's viability and functioning in the long term (Folke 2006).

Within the Living Amazon Vision, well-being, fairness, integrity, and resilience (human and non-human) could become the goals around which all of our economic-political governance systems would be organized. From this shift in the system goal, infinite solutions would emerge to align economic prosperity with ecological vitality. In measuring progress, the GDP would be improved by holistic well-being indicators, including projections of quality-of-life indicators for future generations (Biedenweg *et al.* 2016). Well-being indicators that measure happiness, mental and physical health, sense of belonging, democratic participation, as well as ecosystem and biosphere health could then guide our economic, financial, and public policies. New Zealand, Sweden, Scotland, Costa Rica, and Bhutan have begun making this shift. A variety of indices and methodologies exist that could be analyzed for their suitability, tested, built upon, and adapted[1].

25.2.2 Historical worldviews and emerging alternative frameworks for a Living Amazon

Historically, dominant worldviews, philosophies, and narrative frames, mostly from European outsiders, have shaped the internal and external views of the Amazon region over time, bringing perspectives out of which societal norms, economic and political systems, public policies, and ecological and social outcomes have emerged (Figure 25.1). The premise here is that distinct worldviews are a reflex of the dominant paradigms shaping societal beliefs and values and ultimately influencing politics and history (see Chapter 14). The view of the Amazon as empty lands for imperial ambition (as framed in the 1494 doctrine of discovery), a place containing hidden riches (Myth of El Dorado), or the 18th-century movement that proclaimed that man can improve or tame nature through engineering and technical feats, are examples of religious, cultural, or scientific views that were widely held (Bacci 2010). These framings informed the colonial practices of native and African enslavement, the patterns of the rubber period, the modernization enterprises of the 20th century authoritarian period, the rise of highly globalized extractive economies under conditions of extreme inequality, and the expansion of infrastructure (see Chapters 9–17). Such worldviews could be deeply ingrained, could be contested, could gradually shift or be replaced, or diminish in their influence as humanity's collective understanding of the cosmos and our place in it evolves.

The Historic Frameworks section of Figure 25.1 is an attempt to outline worldviews and cultural assumptions of different time periods about such concepts as "human-nature relationships", "economy", "wealth", and "progress", norms about the treatment of people and nature itself. The Emerging Alternatives section represents more holistic worldviews that are emerging today and that can guide our future actions. Historical views of the Amazon as an infinite storehouse of "resources" to be exploited in pursuit of the goals of "progress" and "economic growth" must be replaced with an Earth Systems Science view, whereby the Amazon is recognized as a key ecological entity of the biosphere's life support system. This emerging Earth systems science perspective aligns with the Indigenous kin-centric worldview in which the landscape and all therein are seen as kin, part of a larger interdependent community, and kinship is essential for mutual survival (Salmón 2000).

It is important to understand that paradigm shifts can happen, and relatively quickly, so what seems unimaginable or immune to transformation can radically shift. For instance, slavery is now viewed with a profound distaste and as a largely inappropriate, private, incorrect, and unacceptable forms of human interaction as norms have shifted. Thus, very profound changes have happened in the past,

[1] Examples of such methodologies are: Gross National Happiness Bhutan; the Genuine Progress Indicator; OECD's Better Life Index; The Thriving Places Index.

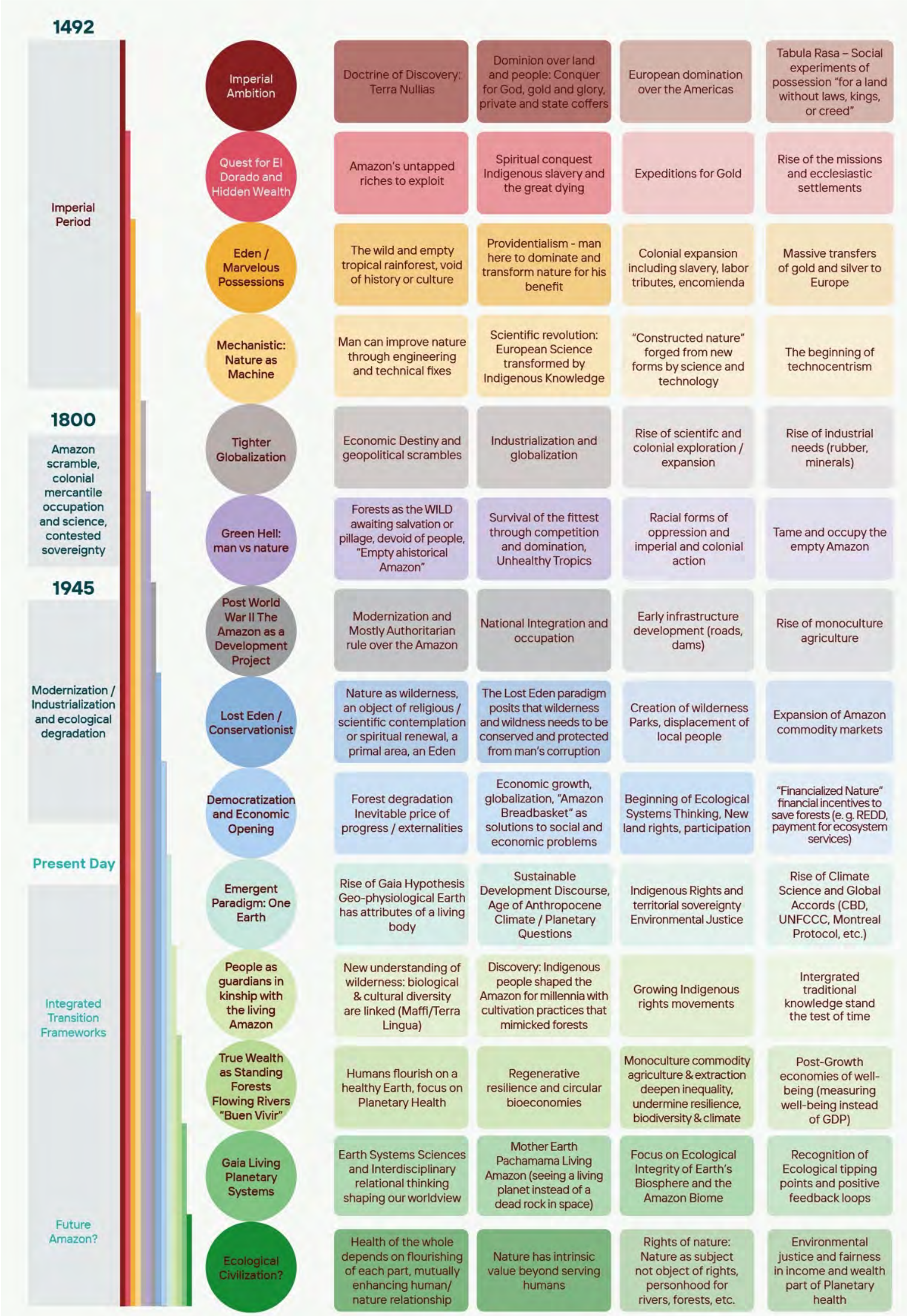


Figure 25.1 Amazon worldviews over time; emerging alternatives to historical frameworks

and new ones can happen again. This possibility is important because of the precarious global and local dynamics in which we find ourselves.

Framing the historical Amazon worldviews is an important step in the process of shaping the Living Amazon Vision and defining systemic problems, as well as designing and advancing effective solutions to the social-ecological crisis facing the region and our planet.

25.2.3 The plurality of social actors, interests, and perspectives in the Amazon

Intrinsic to the worldviews that affect the Amazon, there is a plurality of social actors, interests, and perspectives that interact and compete for territory, natural resources, and ecological co-benefits. Today, approximately 60% of the Amazon population is based in main urban centers (RAISG 2020). As previously documented throughout this report, at least 2.2 million Pan-Amazonian residents are Indigenous peoples from some 410 groups—approximately 80 of which live in voluntary isolation (IWGIA 2020)—speaking more than 300 distinct languages (see Chapter 12). Some Amazonian countries have an expressive or majoritarian Indigenous population, including Peru, Bolivia, Suriname, Guyana, and the French Guiana territory. The Pan Amazonian population is, to a greater or lesser extent, a socio-cultural product of the miscegenation and ethnogenesis between Indigenous, Afro-descendant peoples, settlers, and migrants from different countries (see Chapters 8–13; Chambouleyron and Ibáñez-Bonillo 2019). This mix of identities, cultures, languages, and histories is expressed in diverse worldviews, perspectives, and connections with the Amazon's ecosystems, natural resources, and biodiversity (Figure 25.1, see also Chapter 10).

The multiple worldviews and economic activities that co-exist in the Amazon are also dynamically shaped by historical and political processes, and at times violent conflicts, in a struggle for land, natural resources, ways of thinking and being, and human and territorial rights, which have characterized most of the development trajectory in several Amazonian countries (Hecht and Cockburn 1990; Schmink and Wood 1992; Becker 2004; Ioris 2020; see also Chapters 14-20).

The diverse actors that use, govern, manage, and share the Amazon biome can be grouped in distinct ways according to different purposes. Here, we distinguish actors that: a) live in, use, and manage Amazonian resources; b) public, private, and civil society organizations that manage or govern Amazonian socio-ecological systems; and c) actors who interact with the Amazon, including private companies, multilateral organizations, and investors (Figure 25.2). The state residents include various peoples and sectors, such as IPLCs, forest producers, urban residents, agribusiness producers, and family farmers (Buschbacher *et al*. 2016). These actors are dependent, directly and indirectly, and to a greater or lesser extent, on Amazonian ecosystems and the goods and services they produce. This includes water, energy, minerals, food, fuel, fiber and medicinal products as well as more impactful activities such as deforestation for agribusiness commodities and exports such as soy, cattle and timber.

The diversity of social actors, economic activities, and social-ecological interactions across Amazonian temporal and spatial scales is underpinned by several, and often contrasting, worldviews, interests, and values connected to rivers, forests, soil, and the rich biodiversity shared across the region's geopolitical borders (Biery-Hamilton 2002; Buschbacher *et al.* 2016; Lea 2017; Huambachano and Cooper 2020). Amazonian actors have different views of the value of forested areas or rivers: one might associate it to the market value of the goods and services (instrumental or market value) provided by the forest and rivers, whereas another may express a relational value with the forest/waterbodies by seeing it as kin, a sentient being where powerful ancestral spirits live, and who should be recognized as a subject of rights (Kawsak Sacha Declaration 2018). Others might think about their subsistence or cash livelihoods based on their engagement with forests and waters. Another person may want to conserve the forest for the intrinsic value of animal and plant species, which are products of thousands of years of genetic evolution and have inherent existence rights (Himes and Muraca 2018). Others might view it through the lens of geopolitics, where government power relations define the fate and decision-making over the territories (Becker 2004).

These values can overlap and co-exist in the same individual or across social groups and can be expressed under different contexts and practical situations. However, a historical imbalance of power and socio-economic inequality among different actors has led to the dominance of certain stakeholders' interests and values over others, and to the articulation of dominant monetary values in public policies and organizations within and outside Amazonian borders (Bebbington 2013; Ioris 2015). Over time, these visions have created a set of views based exclusively on monetary value, reinforcing the false rhetoric that standing forests do not produce development. To break this paradigm of trade-offs between development and conservation, it is imperative to recognize, negotiate, and articulate these opposing visions, addressing conflicts and promoting the recognition of the multiple values of standing forests, free-flowing rivers, and of the Amazon socio-biome at large. Circular economies and bioeconomies need to create nature-based opportunities and solutions so that people that do not see the value in the standing forest start to see it, and the ones that already do can in fact improve their quality of life with it (see Chapter 30).

The SPA Living Amazon Vision emphasizes the need to reconcile economic and ecological security and prosperity with social justice and ecological integrity and diversity, entailing a more inclusive, democratic, and participatory process of knowledge production and decision-making, plural valuation, and innovative multi-level governance arrangements amongst Amazonian social actors (see also Chapters 31–33). These arrangements will be critical to the success of an Amazon-based bioeconomy and other nature-based economic arrangements for the region (see Chapter 30).

Experiences of governance and management of Indigenous territories and collectively managed areas, in various co-management arrangements with collective, public or private actors, provide important contributions to a post-COVID-19 Living Amazon Vision. Amazon–Andes-based Indigenous philosophies and concepts have inspired local, national, and international policies and social movements, including the Rights of Nature movement, the *Buen Vivir* (Living Well), and *Pachamama* concepts and values, which have been incorporated in National Constitutions (Bolivia and Ecuador), and in national, regional, and local development policies and practices (although with recognized inherent constraints and pitfalls), with special provisions for Indigenous peoples and Afro-descendant communities (Fleuri and Fleuri 2018; Williford 2018). These philosophies are based on principles and values of collective human-nature well-being, reciprocity, respect for the past, commitment to maintaining the collective human-nature well-being into the future, and fair compromise between past and future. These principles and values can be engaged with economic instruments and global policies, including agreements on Climate Change, Environment Social and Governance arrangements (ESGs), and ideas and normative positions such as SDG indicators (van Norren 2020).

Promoting a wide Pan-Amazonian dialogue on the main principles and values proposed by this report would be an important step to jointly address this emergency in an attempt to stop and revert the trajectory of destruction and degradation that humans are inflicting on the Amazon, which is within the timeframe of this generation (Lovejoy and Nobre 2018).

25.2.4 The regional and global vision for the Amazon

The protection, sustainable management, and res toration of tropical forests, rivers, and associated ecosystems (see Chapters 27–29) is key to meeting global climate, biodiversity, and Sustainable Development Goals. Sustaining a Living Amazon Vision would mean realigning strategies and relationships between stakeholders interacting with the Amazon (Figure 25.2), aligning policies, and innovating and supporting alternatives to monocultural development and unsustainable extractive and extensive economic activities (Zycherman 2016; Hoelle 2017; Soares-Filho and Rajão 2018; Müller-Hansen *et al*. 2019).

Beyond domestic investments and incentives in a proactive agenda to achieve the Living Amazon Vision, financial support should be mobilized from developed countries, as they have a deep responsibility both as buyers of products from areas associated with deforestation and for their accumulated greenhouse gas (GHG) emissions. Supply chain actors, such as companies, investment funds, and portfolios that trade and utilize Amazonian products including land, can mobilize for sustainable production, and should provide transparent information to consumers and investors about their sourcing and investment (Gardner *et al*. 2019). Setbacks on environmental agendas can lead to restrictions on the economies of Amazonian countries. One example is how the current deforestation rates in Brazil have become so critical that they may undermine the MERCOSUR trade agreements with Europe (Gonzalez 2021).

Global cooperation, robust diplomacy, and mutual responsibility are essential for achieving sustainability in the Amazon. Sustainable development pathways for a Living Amazon must be shaped and implemented by Amazonian countries and supported by other nations. The United Nations (UN) Convention on Biological Diversity (CBD), the Nagoya Protocol on Access and Benefit Sharing for the genetic use of biodiversity, the UN 2030 Agenda for Sustainable Development, and the UN Framework Convention on Climate Change (UNFCCC) Paris Agreement on reducing global climate change, are important and relevant multilateral agreements with a significant impact on the future of the Amazon. All eight countries in the region, as well as French Guiana, explicitly include forest protection in their Nationally Determined Contributions (NDCs) to the Paris Agreement (Wong *et al*. 2019). Brazil's massive reduction of deforestation from 2004–2012 through a series of public policies, as well as private and cross-sectoral measures (see Chapter 17; Assunção *et al*. 2013; Nepstad *et al*. 2014), is a conservation success story that led to the Amazon Fund (Correa *et al*. 2019), even though it was dependent on a complex of activities and global conjunctures (i.e., multilateral engagement on climate change agenda, the rise of green market requirements, world economic crisis) (see Chapters 14 and 15). Nevertheless, these gains were achieved in part by forest clearing elsewhere, such as in the Chaco, Cerrado, and Chiquitania of Bolivia, as a form of avoiding regulations and seeking lower land prices (de Waroux *et al*. 2019). To avoid these leakages in a Living Amazon Vision, it is important to accommodate and harmonize trans-regional and trans-national policies to protect neighboring biomes, as they are also crucial for supporting regional ecological integrity and human well-being.

Regional and cross-country cooperation and coordination are needed to protect forests and restore degraded lands. The Governors' Climate and Forests (GCF) Task Force, a network of 35 tropical states and provinces in eight countries, including Brazil, Peru, Colombia, and Ecuador, has highlighted the role of subnational governments as leaders in sustainable development. In 2014, the members of this task force pledged to reduce deforestation by 80% in their respective jurisdictions' by 2020, contingent on adequate finance (GCF Task Force 2014). In 2019, the national governments of Colombia, Bolivia, Ecuador, Peru, Suriname, Guyana, and Brazil signed the Leticia Pact, which includes commitments to share information and coordinate efforts to fight deforestation and wildfires and restore degraded areas in the region. However, subnational jurisdictions and countries have yet to meet their commitments.

All initiatives emphasize the importance of empowering Indigenous peoples and local communities, paying special attention to gender equality, and engaging the private sector in sustainable finance as key requirements for meeting their goals. In addition, the Amazon Cooperation Treaty Organization (ACTO), an intergovernmental organization formed by the eight Amazonian countries, was created in 1995 to encourage sustainable development and social inclusion in the region. The "Amazon Vision" is another initiative that intended to integrate and engage countries in protecting biodiversity, producing a ten-year action plan (2010–2020) incorporating new strategies and proposing investments and financing plans, all in compliance with the Aichi Biodiversity Targets and the strategic plan of the Program on Protected Areas (PTAP) of the CBD. Implementation of this work plan resulted in a joint declaration to the COP 21 highlighting the importance of protected areas for climate change adaptation and mitigation signed by 17 countries, including all Amazonian countries, except for Suriname. However, ownership of this vision beyond the environmental sector and across scales has not been achieved (Redparques 2019).

It is paramount to strengthen cooperation among Amazonian and non-Amazonian countries' governments, civil society, financial institutions, private sector, and IPLC organizations to build the Living Amazon Vision. This includes supporting *inter alia* agroforestry and fisheries practices, forestry, and other products connected to the region's socio-biodiversity that support the Amazon-based global economy (see Chapters 27-29).

25.2.5 Experiences of sustainable development in Amazonian countries

There has been a long history of sustainable development interventions in the Amazon, which have attempted to balance forest conservation with livelihood development and could be used to pave the way for the Living Amazon Vision. These experiences have distinct scales, from local projects to regional policies. Among them, there is the creation of sustainable-use protected areas, integrated conservation and development projects (ICDPs), and payments for ecosystem services schemes (PES; see Chapter 30), implemented over the years with varying degrees of success (Börner et al. 2020). Some of these experiences are identified in the SDSN-Amazonia Map (SDSN-A 2021), which presents the spatial distribution of initiatives linked with the SDGs. These are only a small portion of initiatives that have been part of decades of history of domestic and international investments, many of them invisible at scale, but that has helped to shape the evolution of local, regional, and global solutions to achieve sustainability.

At the country and government level, there are some relevant initiatives to support standing forests that are worth mentioning in terms of persistence and scale. Since 2008, the Socio-Bosque program or "forest-partner" run by the government of Ecuador offers economic incentives to landowners to preserve their native forests over the medium to long-term through conservation agreements. The program has signed 630,000 hectares for conservation so far (de Koning et al. 2011). The National Program for Sustainable BioTrade (Biocomercio Sostenible) implemented in Colombia, which aims to support sustainable businesses based on biodiversity products and services, is another example of how governments have started to recognize the economic potential of biodiversity conservation to businesses (Garcia Rodríguez et al. 2015). In Peru, the National Forest Conservation Program relies on payments to Amazonian Indigenous communities as an incentive for them to avoid deforestation and adopt sustainable practices, generating modest conservation impacts (Giudice et al. 2019). The Brazilian Bolsa Verde (Green Grant) Program is another example of a public policy aimed to support forest-based local communities living at poverty levels to support their livelihood while sustainably managing their natural resources, reducing the pressure to substitute the forest with pasture and crop fields. The program is currently discontinued due to political reasons, but it had an important impact on supporting local communities that are at high poverty levels and developed a successful multilevel governance approach for its implementation (Kull et al. 2018).

Among the experiences that aimed to promote forest conservation while sustainably boosting the local economy, one that engaged diverse global stakeholders around the objective of maintaining Amazon forests standing as a way to mitigate climate change was the REDD+ mechanism. REDD+, which stands for reducing emissions from deforestation and forest degradation, along with the conservation and sustainable management of forests, and enhancement of forest carbon stocks, emerged in the context of the UNFCCC negotiations over a decade ago (Moutinho et al. 2011). This mechanism is now enshrined in the Paris Agreement and was seen as a potential win–win for conservation and development, providing financial incentives to forest-rich countries for maintaining standing forests (Angelsen and Wertz-Kanounnikoff 2008).

Brazil, Colombia, and Ecuador have fulfilled all UNFCCC requirements to access REDD+ results-based payments from the Green Climate Fund. Since 2019, the Green Climate Fund has committed to paying Brazil USD 96.5 million for forest-based emissions reductions in 2014–2015, Ecuador USD 18.6 million for results achieved in 2014, and Colombia USD 8.2 million for 2015–2016. Norway has also invested heavily in Brazil and Guyana: Brazil's Amazon Fund (2008) was the largest climate pay-for-performance mechanism ever created (Duchelle et al. 2019; Figure 25.3).

It is important to understand how such international investments have affected forests and people in the region. Although most national REDD+ initiatives have so far failed to stop deforestation, REDD+ finance has contributed to a better understanding of deforestation drivers, stronger and improved forest monitoring capacities (e.g., Brazil, Colombia, Guyana; Laing 2018; Nesha et al. 2021), engagement of local and regional stakeholders in national forest policy discussions, and improved policy coordination among national ministries involved in forest governance (e.g., Brazil, Guyana, and Colombia; Griscom et al. 2020). For example, in Guyana, the REDD+ support from the Memorandum of Understanding with Norway resulted in the USD 250 million of performance-related payments made to the country over five years and was inextricably linked to a wider national development policy and planning process, which is encapsulated in Guyana's Low Carbon Development Strategy (LCDS), in 2009 and 2010.

Although Brazil's success in reducing Amazonian deforestation by approximately 80% from 2004–2012 (see Chapter 17) largely predated the bilateral agreement with Norway, some have argued that the agreement helped consolidate the political will needed for continued progress (Seymour and Busch 2016). It also incentivized the leadership of subnational states and provinces, such as Acre (Brazil), which aligned its decades-long sustainable development policies through the state System of Incentives for Environmental Services (SISA) (Alencar et al. 2012; Schmink 2014) to become a global model for jurisdictional REDD+. The local government, which had previously seen the forest as a burden for development, started to engage in creating solutions (i.e., Acre's SISA) and articulating policies (i.e., Mato Grosso state policy's Produce, Conserve and Include - PCI). In the case of Brazilian states, resources channelized through the Amazon Fund helped to support Amazonian states with insufficient funds to invest in better state environmental governance systems. The Brazilian Rural Environmental Registry (CAR), which today is one of the most important databases used to identify challenges and design policies for rural areas of Brazil, had fundamental support from the Amazon Fund (Roitman et al. 2018).

Even though REDD+ initiatives, as individual projects or jurisdictional programs, have led to decreased forest clearing (Simonet et al. 2019) and helped improve livelihoods (CIFOR 2018; Souza and Alencar 2020) in some places, REDD+ is not a silver bullet. A major challenge is that the scale of REDD+ finance has paled next to its business-as-usual competition, with the lack of incentives for forest conservation contributing to the environmental and social backsliding experienced in Brazil in recent years. Furthermore, land tenure insecurity remains a key barrier for REDD+, and it is critical to prioritize the rights, participation, and livelihoods of local farmers and communities, including women, in forest-based climate mitigation initiatives to ensure more effective and equitable outcomes (Duchelle et al. 2019). Another problem has been the leakage of destructive activities away from the REDD sites.

The broader challenges to engage in a Living Amazon agenda are the integration and articulation of various conservation and development initiatives, including REDD+. Strategies of integration must be founded on solid principles and values and articulated in innovative and enduring pillars that highlight the importance of the Amazon across scales (e.g., local, national, and global). They must sup-

Figure 25.3. The density of REDD+ initiatives at a national level and the existence of REDD+ policies/programs at the subnational level. Adapted from the International Database on REDD+ projects and programs; Simonet et al. 2019; Duchelle et al. 2019.

port possibilities of innovation in a new bioeconomy paradigm, as well as embrace more democratic and representative governance systems.

25.3 Principles and Values for a Living Amazon

Building pathways towards dialogue, negotiation, and articulation of distinct visions on the future of the Amazon is fundamental to developing common principles and values. Values represent intrinsic qualities that influence people's behaviors to achieve a common vision, whereas principles represent a proposition, an objective reality to be followed to guide people's behaviors towards a new vision for the Amazon. Six values and seven principles were highlighted to support the Living Amazon Vision proposed in this chapter. This vision incorporates aspects of the sustainable development triad framed here as ecologically healthy, economically prosperous, and socially fair (Table 25.1). Below, values and principles will be discussed jointly, as they reinforce each other.

25.3.1 The Amazon is the world's largest tropical rainforest and largest river by volume with a unique geodiversity, exceptional biodiversity, and high level of endemism, which must be valued, respected, and protected

The Amazon is a living, active, complex, dynamic, and diverse system (Jézéquel et al. 2020), which is a product of evolution and co-evolution of natural and human interaction with values that go beyond utilitarian in terms of products and services. This principle recognizes the rights of nature, particularly the right of ecosystems to maintain their integrity and their evolution. It is based on a biocentric worldview that recognizes nature's existence or intrinsic value, in contrast with a predominant anthropocentric worldview, in which human wellbeing is viewed as superior or more important than other beings' existence Nesshöver et al. 2017). This includes geological resources being well managed to avoid permanent damage to the landscape and impacts on all forms of diversity, more investments in science to fill the knowledge gaps about this complex and diverse systems, and the promotion of the importance of geodiversity to human-environmental well-being to leverage societal dialogue and engagement in conservation.

25.3.2 The Amazon provides key, cross-scale regulatory ecosystem functions, especially for climate, hydrology, and biodiversity that form the basis of water and food security

The Amazon functions as a critical entity in the hydro-climatic life support system of the Earth's biosphere and key ecological processes at multiple scales. This second principle is associated with the significant local, regional, and global climate benefits from the Amazon (described in section 1), from preserving carbon stocks to maintaining hydrological equilibrium and supporting the health and resilience of terrestrial and aquatic systems. It recognizes that the globe is one large interconnected system and the integrity of the Amazon represents an important piece of that system (Baker and Spracklen 2019). Therefore, it is essential to acknowledge that depletion of the Amazon terrestrial and aquatic systems would have profound impacts that percolate across scales. The health and integrity of the Amazon terrestrial and aquatic systems, including well-functioning ecological processes and connectivity, are essential to improving people's quality of life. Consequently, it is imperative to consider the Amazon in its totality to promote trans-national governance and management strategies and policies to guarantee the integrity of the Amazon as a living support system of the globe.

25.3.3 Use of the Amazon's natural resources must support ecological processes, functions, and livelihoods in the face of a climate crisis and a potential tipping point

This principle is embedded in the diversity and natural socioeconomic vocation of the Amazon. It highlights the value of diversity of production strategies and livelihoods in the region and their interdependence with ecosystem services. It also highlights the Amazon as a potential world bio-

Table 25.1 Principles, values, and keywords that shape the new Amazon vision.

Principles	Values	Keywords
1. The Amazon is a geodiverse and biodiverse system that must be valued, respected, and protected.	1. The Amazon holds the world's largest tropical rainforest and the largest river by volume, with a unique and complex geodiversity, exceptional biodiversity, and a high level of endemism.	Diversity, Uniqueness, Complexity
2. Amazonian ecosystems' functions provide benefits at multiple scales.	2. The Amazon provides key, cross-scale regulatory ecosystem functions, supporting climate, hydrology, and biodiversity, forming the basis of water, energy, food, and income security.	Connectivity, Cross-scalar, Integration, Teleconnection
3. Use of the Amazon's natural resources and its ecosystems must support ecological processes, functions, and livelihoods in the face of a climate crisis and potential tipping points.	3. Amazonian peoples hold diverse and interconnected livelihood strategies that can form the basis of a future world bioeconomy.	Interdependency, Responsibility, Reciprocity
4. Urban and rural areas of the Amazon must function as integrated productive systems that promote and support a wide range of socio-economic and ecological benefits.		Identity, Integration, Innovation, Decentralization
5. Amazonian governance must include participatory processes of engagement between diverse stakeholders and across scales for the well-being of the whole.	4. The Amazon holds diverse worldviews, values, institutions, and governance systems that have contributed, and should continue to contribute, to the shaping of pluricultural, inclusive, and democratic societies.	Engagement, Participation, Inclusion
6. The Amazon houses diverse experiential knowledge systems and cultures resulting from the connection between people and nature, or biocultural diversity, which must be valued, recognized, and protected.	5. The Amazon holds high levels of cultural and linguistic diversity and provides an opportunity for collaborative knowledge production and sharing in relation to sustainable resource use.	Knowledge, Diversity, Collaboration
7. Recognition of the rights of Indigenous peoples, Afro-descendant, and other local communities and ensuring their access to justice is paramount to promoting well-being for all.	6. Recognition of the territorial rights of IPLCs reduces conflict, promotes equity, and increases human-nature well-being.	Rights, Justice, Equity

economy leader (Valli et al. 2018). It assumes forest- and water-based activities, or other economic activities and practices that support forest and aquatic systems and services, as the main activities promoted and supported in the Amazon. Thus, whether properties are private, state, or common, the result of forest and water use must sustain the integrity of the ecosystem services and functions provided by them. This principle ensures the renewal of natural resources, recognizing the limits on the extent and intensity of their use and avoiding large-scale extractive economic models that consider the Amazon as a region of inexhaustible wealth focusing on short-term profit maximization (Frey et al. 2018; Sauer 2018). It acknowledges synergies, feedbacks, and interactions of climate, ecosystems, economic activities, and associated infrastructure, thus preventing the impact of these activities on extensive forest loss, river flow, and baseflow, alteration of the energy balance, and the release of carbon to the atmosphere (Guimberteau et al. 2017; Latrubesse et al. 2017).

25.3.4 Urban and rural areas of the Amazon must function as integrated productive systems that promote and support a wide range of socio-economic and ecological benefits

This principle addresses the fact that the Amazon has a strong urban character, and rather than the usual trajectory of countryside occupation, it is gradually shifting into towns and cities (Padoch et al. 2008). Amazonian cities possess a particular matrix of historical, social, and spatial dynamics that enable people to incorporate aspects of Amazonian agroforestry as key assets for the creation of resilient survival strategies on the urban periphery (Costa and Brondízio 2011; de Souza and Alvalá 2014). Hence, this principle is based on the importance of including Amazon cities in the perspective of integrating development and conservation, and the urban with the rural areas, to enhance their mutual socio-ecological and economic benefits. In this principle, the Amazon should invest in more "urban forests", in which cities are less reflective and contain more green productive spaces that provide habitat value for biodiversity and agrobiodiversity production. Based on this principle, the "urban forest" may be a source of innovative jobs and industries that connect with forest and river use in rural areas in a sustainable form, strengthening the identity of Amazon's citizenship and the urban/rural relationship.

25.3.5 Amazonian governance must include participatory processes of engagement among diverse stakeholders and across scales for the well-being of the whole

In the Amazon, the governance of common goods requires not only strong government and institutions (i.e., trained people, appropriate infrastructure, sufficient financial support), but also balanced participation in the decision-making process inclusive of diverse worldviews at different scales (Thaler *et al.* 2019). A desired governance system for the Amazon provides equal opportunities for representation and participation in decision-making processes regarding territorial and natural resource use rights. It is fundamental to protect the array of IPLCs' territories and provide equal opportunities for participation. This principle reinforces the proposition that any decision-making process must involve local people and communities, use the best scientific knowledge to assist in decision-making, value Indigenous and local knowledge (ILK) and cultural practices to assist in decision-making, and ensure public participation and integration of actors/stakeholders from local to international scales. Therefore, it must encompass the following elements: strong and articulated institutions; equity, justice, and rights policies; inclusive decision-making processes that can be referred to as the enabling environment; improved access to information; cross-sectoral articulation and cross-scale alignment that are bridging mechanisms for greater and more effective input from civil society. These are reflected in new models of trans-basin and transboundary cooperation and local activism, which end up creating and reinforcing a collective identity of the Amazonian people.

25.3.6 The Amazon houses diverse experiential knowledge systems and cultures resulting from the interconnection between people and nature, which must be valued, recognized, and protected

The Amazon hosts a range of symbolic, spiritual, and material values that reflect the diversity of IPLCs and their interactions with nature (Millenium Ecosystem Assessment 2005; Hirons *et al.* 2016). This principle acknowledges how diverse cultural heritage knowledge systems of Amazon Indigenous peoples and local communities are formed and are of special value, needing to be respected, protected, and shared (Olsson 2011). It considers ancient knowledge as a public good that should not be seen merely as the product or possession of individual minds but built and used collectively and dependent on social and physical environments (Athayde *et al.* 2016). This knowledge is fundamental for society to gain a deeper understanding of the Amazon human–nature relations, which is also crucial to promote sociocultural, environmental, and economic sustainability (see Chapters 30 and 33). This knowledge must be protected from private expropriation and biopiracy while at the same time highlighting the potential for dialogue, exchange and articulation within and between IPLCs knowledge systems, scientific knowledge and policy-making in order to inform pathways toward sustainable resource use and sustainability of the Amazon (see Chapter 33).

25.3.7 Recognition of the rights of Indigenous peoples and local communities and ensuring their access to justice is paramount to promoting well-being for all

Amazonian IPLCs have played an important role in shaping, protecting, and restoring Amazonian ecosystems and biodiversity under different changing contexts, despite genocide, violence, displacement, and conflicts between conservation, livelihood, territorial, and development agendas (see Chapters 8–14). Criminal activities are driven by the demand for high-value resources such as timber and gold and take advantage of weaknesses in the justice system, particularly in border regions, affecting the integrity of IPLCs territories and lives (Villén-Pérez *et al.* 2020). The responsibility behind ecosystem degradation in the Amazon, resource consumption, and hence the planetary crisis is not equally distributed, nor is the vulnerability to this degradation. To promote justice and well-being among peoples that support conservation and depend on natural resources for their livelihoods, there is a need for improved frameworks to defend

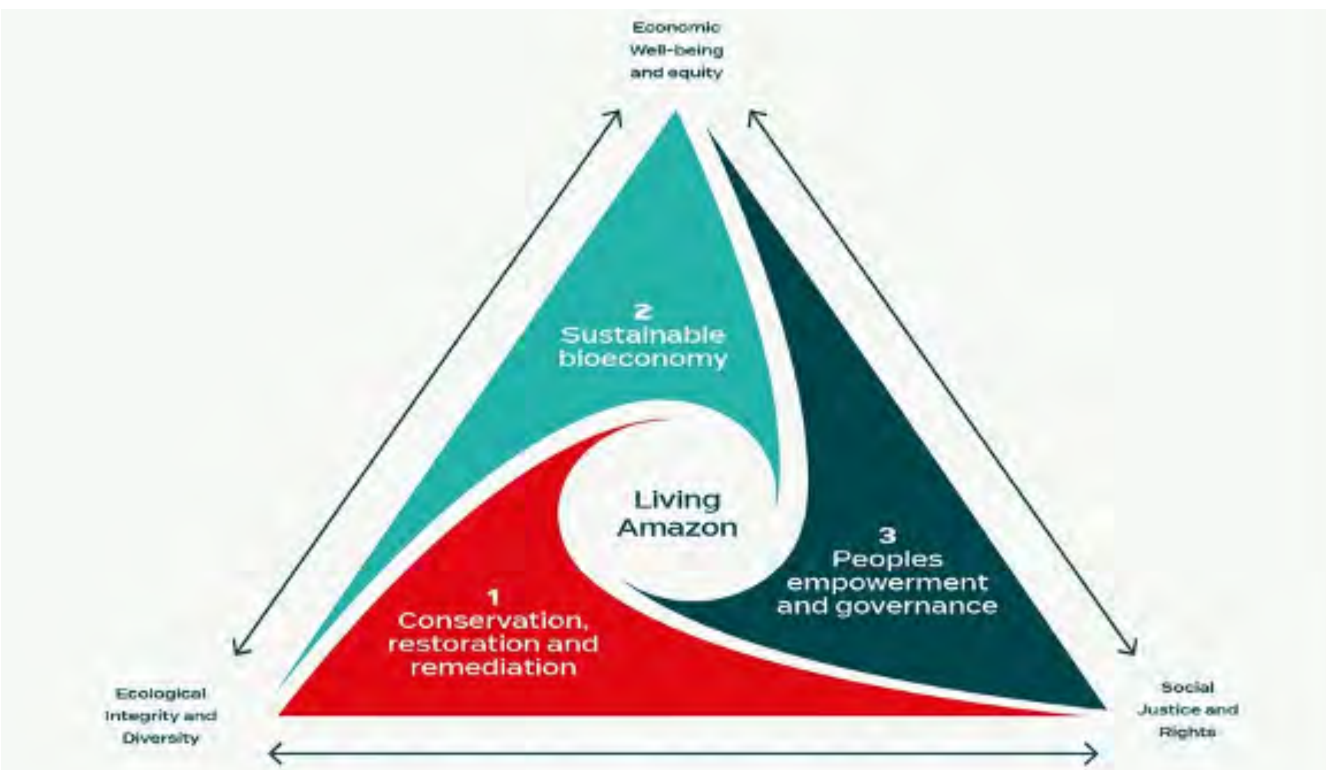


Figure 25.4. Pillars of the Living Amazon and its relation with aspects of the sustainable development tripod.

the collective territorial rights of IPLCs, the rights to a healthy environment for all citizens of today and tomorrow (Living No One Behind principle of the UN Agenda 2030 and SDGs), and the safety of local defenders of nature (see Chapter 31). This principle highlights the importance of recognizing IPLCs' rights to healthier landscapes, to their well-being, and the well-being of the region and the planet. A human rights approach to achieving sustainable livelihoods and well-being is essential to reframe the Amazonian development model to the pursuit of a Living Amazon Vision toward just and sustainable futures for current and future generations.

25.4 Pillars of the Living Amazon

Based on the principles and values described above, we propose a strategy to support a Living Amazon based upon three pillars. The strategy is inclusive and just, and will promote healthy societies, environments, and economies. These pillars are associated with (i) the incentives for conservation, sustainable management, restoration, and remediation (i.e., removal of pollution) of ecosystems, (ii) the incentive for the development of an inclusive bioeconomy, and (iii) the strengthening of governance and people's empowerment (Figure 25.4).

These pillars are inspired by the three dimensions of sustainable development and their desired outcomes: a) the ecological integrity of the terrestrial and aquatic ecosystem; b) the economic dimension represented by socio-economic well-being and equity, and c) the social aspect represented by social justice and rights. They are organized in three objectives and strategies described below (Figure 25.5), and will be further discussed in Chapters 27–34 of this report:

25.4.1 Measures to conserve, restore, and remediate terrestrial and aquatic systems

25.4.1.1 Expand, consolidate, and secure protected areas

The Amazon protected areas, which include Indigenous territories and other types of conservation lands (i.e., national parks, ecological stations, nature reserves, extractive reserves, sustainable development areas, and Afro-descendant territories), have been acknowledged as efficient strategies of conservation in the Amazon to protect both natural and cultural systems (Nepstad *et al*. 2006; Nolte *et al*. 2013; see Chapter 16). In the Amazon, at least half of the standing forests are inside formally protected areas (RAISG 2020) and the protection and consolidation of these territories as sustainable drivers of conservation is the first step to support human-nature well-being and the Basin ecosystem integrity. Nonetheless, these areas were not initially designed to protect river systems, indicating a need for redesign and expansion (Opperman *et al*. 2021). Rivers frequently serve as boundaries of protected areas, and often, only tracts of them are located within the protected area. The protection of free-flowing rivers is essential for freshwater biodiversity conservation and protecting the livelihood of IPLCs that depend on them (e.g., fisheries).

Nonetheless, instead of expansion, these areas have been seriously threatened in recent years (RAISG 2020), being downgraded, downsized, and degazetted (PADDD; see Chapter 16), indicating the need for action and strong political will towards their protection (Kroner *et al*. 2019). Policies designed to support sustainable use and protection of these territories (i.e., Amazon Region Protected Areas Program - ARPA) and that go beyond conservation are important elements to protect and consolidate these areas and promote them as sustainable drivers of conservation in a Living Amazon Vision. Some of these policies initiatives include: a) support IPLCs livelihoods (i.e., education and health); b) discourage forest conversion to extensive land uses (i.e., cattle ranching); c) encourage the expansion of protected areas considering the protection of freshwater biodiversity and fisheries; d) strengthen the capacity of institutions responsible for managing and monitoring these areas (i.e., people, infrastructure, technology); and e) articulate and implement transnational programs to promote connectivity among them.

25.4.1.2 Cease deforestation, degradation, and contamination of terrestrial and aquatic ecosystems

Controlling the loss of Amazon forest and the human impacts on rivers (i.e., pollution by mining, wastewater, plastic, damming) is a centerpiece and one of the main goals in a Living Amazon Vision. Important strategies that need to be strengthened to impede forest and freshwater degradation and the voluntary expansion of non-forest land-uses over forest areas include a) strengthening the governance of land and natural resources; b) improving and supporting monitoring and enforcement; c) providing economic incentives for good practices in areas already deforested or polluted; and d) engaging the public and private sector organizations, including companies in zero-deforestation and freshwater protection agreements (Stabile *et al.* 2020). This would help to restrain illegal deforestation on public lands (i.e., in the Brazilian Amazon, where at least half of deforestation happened on public lands; Alencar *et al.* 2021), and illegal logging and mining, which are important drivers of degradation of both terrestrial and aquatic systems. Private landholders need to be encouraged to go beyond following the deforestation restrictions imposed for each country, using incentives so they can engage in more sustainable land-use practices. Licensing policies for infrastructure such as large dams, hydroways, roads, mining operations, and industries must be strengthened and enforced to reduce the impact of pollution and degradation on freshwater systems (see Chapter 20). In addition, waste treatment policies should guarantee potable water for Amazonian people in both urban and rural areas.

25.4.1.3 Restore and remediate landscapes and watersheds for maximizing multiple ecosystem services

To safeguard the ecological integrity of the Amazon biome, it is not only necessary to halt the loss and degradation of natural resources and support the consolidation of protected areas, but also to restore and remediate terrestrial and aquatic ecosystems in deforested, degraded, or contaminated areas. In the Amazon, at least 867,675 km^2 was deforested by 2018 (Mapbiomas 2020), and most of it (80%) was converted to pasture (RAISG 2020). In Brazil, which accounts for 85% of the deforested area in the region, it is estimated that 60% of the area once deforested is either heavily degraded pasture or abandoned (Mapbiomas 2020). In addition, infrastructure and mining have impacted and polluted Amazon rivers (Castello *et al*. 2013). Under a Living Amazon paradigm, there is a need to restore the integrity of these areas and strengthen conservation strategies and policies already in place. These processes must include the restoration of deforested or degraded riparian areas to support forest–river connectivity and ecological functions that support biodiversity (Alvim *et al.* 2020). This measure is legally obliged in some countries such as Brazil, but their riparian widths are still insufficient to protect biodiversity and essential ecological processes (Dala-Corte *et al*. 2020). It also reinforces the recovery of other priority areas that are not necessarily connected by rivers but hold value for endemic and endangered species (Chapter 27 and 29) and provide fundamental ecosystem services. The remediation of areas polluted by mining, pesticides, and industries or disrupted by infrastructure activities is also vital (Chapter 28). In addition to existing restoration strategies, including passive natural regeneration and active induced restoration, silvopastoral systems may also be used to provide economic and other social benefits from restoration (see Chapters 27–29).

25.4.1.4 Implement systems to monitor, evaluate, and hold stakeholders accountable for restoration and remediation

To be effective, restoration and remediation processes require that several prerequisites are met, including policy and legal enforcement, identification of priority areas to be restored in which multiple ecosystem services are maximized; implementation of payment for environmental services; societal participation and engagement; strong and transparent monitoring systems; and social and market-based incentives and investments for restoration. A monitoring system, with a clear framework of accountability and enforcement, to encourage engagement and support, while avoiding leakage and additionality, is also essential. The creation of an Amazon restoration fund, and/or the reinstatement, expansion, and strengthening of the Amazon Fund, would help to support stakeholders' priorities in conservation and restoration. These efforts would also support tree planting in and around Amazonian cities, promoting climate comfort and reducing the impact of heat islands (see Chapter 29), and large-scale passive restoration of watersheds and biodiversity corridors, supporting healthy rivers and protecting freshwater habitats and biodiversity. In addition, these efforts must be transnational and incentivized as crosscutting policies influencing more than restoration and remediation, also supporting transboundary integrated Basin management and large-scale conservation.

25.4.1.5 Implement global and regional incentives for conservation, restoration, and remediation

There is a need for a comprehensive Living Amazon Conservation and Restoration Pact between all Amazonian countries and backed globally. Such a pact would include a clear target and regional criteria for the percentage of forest cover that must be protected and restored to avert the potential tipping points. Beyond the 30% protection target being discussed within the Convention on Biological Diversity, and more than the proposed Nature Needs Half targets, ensuring the integrity of Amazon's hydrological system would require an estimated 80% of forests to remain standing (Lovejoy and Nobre 2019). These targets must consider regional differences regarding the level of conservation of remaining forests. Although the 80% target has been followed by all Amazonian countries so far (Smith *et al.* 2021), some regions of the Basin are below this threshold. The eastern Amazon is an example of that, trespassing this threshold and impacting carbon and water fluxes with potential implications to other portions of the Amazon that are still preserved (Gatti *et al.* 2021). Thus, significant restoration efforts in highly deforested areas, in addition to conservation efforts in well-preserved areas, are essential, independent of the global proportion of deforested lands in the entire Amazon, and must be part of Pan-Amazonian countries' urgent agenda. There is boldness and clarity in committing to such a target, which would focus the governments of the Amazon and the world and the private sector, on their shared, yet different responsibilities and contributions to solution pathways for achieving such a goal. There is also a need for regional and global investment for conservation, restoration, and remediation activities. Innovative financial incentives for ecosystem conservation and restoration must be accessible and supported, and restoration should be considered part of a green economy that generates socio-economic benefits, including jobs, while mitigating climate change. These efforts must be counted as part of the well-being indicators as an alternative to the dominant GDP in a Living Amazon Vision.

25.4.1.6 Signaling Urgency

There is an urgent need for the Amazon Basin countries to declare a state of emergency and call for a "ceasefire" for illegal activities, including mining, drug trade, logging, and land grabbing, which cause deforestation and degradation of forest and rivers, social conflicts, and violation of the rights of Indigenous peoples and other communities. This means detaining, with a national and international police force, the criminal organizations that are undertaking the governance of the agriculture frontier in the Basin and halting illegal deforestation and degradation that is auto-financed by drug trade, illegal mining and logging, and land grabbing (Schönenberg 2019; McSweeney *et al.* 2017; see also Chapter 27). International commitments to work together and dismantle these illegal operations among Amazonian countries, as well as the Global North countries that are also part of the demand for the products from illicit activities in the region, is key to reducing the demand for the consumption of these products and removing the money from illegal supply chains including drugs, gold, timber, and animal trafficking, among others. In addition to battling illegal activities, it is necessary to halt industrial operations and government policies that enable further forest and river destruction (e.g., the suspension of new operation licenses and new private and public financing for mining, oil, cattle ranching, large dams, and other industrial activities that promote deforestation and degradation). Governments, financial institutions, and corporations would need to commit to respecting the state of emergency to allow time for longer-term agreements to be negotiated. Such agreements would build on prior attempts to achieve zero deforestation, deforestation-free supply chains and investments, robust diplomacy, and commitments to leave fossil fuels in the ground. They would also require supply chain and financial commitments from the global community and importing nations to fund the solution pathways to support workers and sectors most affected in the transition. Finally, they would need to promote institutional innovation and adaptive capacity, including physical and human resources and the ability to anticipate and effectively respond to environmental and other changes.

25.4.2 Developing sustainable and circular bioeconomy arrangements for standing forests and flowing rivers

25.4.2.1. Invest in the research, marketing, and productivity of Amazonian socio-biodiversity products

The mainstream Amazon forest/river-based economies, even if intrinsically diverse, have been mostly based on timber extraction, harvesting of non-timber forest products (NTFPs) (i.e., rubber, vegetal oil, fruits), and fishing; some of these products have had a strong export demand. Besides timber, a few NTFPs and the commercialization of a few fish species, the majority of Amazon forest/river-based products and their potential economies have not been valued (see Chapters 20 and 30). Important barriers for this to happen are the lack of investment in science, technology, and adequate infrastructure to improve the production system, improve quality, and develop sub-products that are more attractive to the market and economically viable to produce. In a Living Amazon Vision, a different economy that values the diversity of products and services provided by forests and rivers becomes the fundamental strategy for future regional sustainable development. A strong market developed based on socio-biodiverse products that result from the interactions between the biological diversity and cultural and ancestral ways of managing forest and water resources can bring important investment to the region in a sustainable and fair way. Some elements are imperative to promote such a shift. First, there is a need to direct investment to understand and quantify the real size of the socio-biodiversity economy operated in the Amazon. The invisibility of these economies makes it challenging to design and realign policies to support and promote them, besides demonstrating their real value compared with extractive non-forest/river-based economies. Second, it is fundamental to foment organized market strategies, reducing the unbalanced quality of the products and increasing the chances of meeting the demand for socio-biodiverse products. Third, it is essential to support local value socio-biodiverse product aggregation with investment in science, technology, and infrastructure, as well as marketing strategies to engage the society to recognize the co-benefits to support the consumption of forest/river products associated with Amazonian biocultural diversity.

25.4.2.2 Create fiscal incentives to engage the private sector and multilateral institutions in innovation around Amazon products

There is a need to elaborate and strengthen the concept of a sustainable bioeconomy in and for the Amazon. This concept must be decoupled from, and go beyond, the simple forest/river extraction economy. The Amazonian countries can emerge as protagonists of a global bioeconomy, based on the values of socio and biocultural diversity and their services. This will demonstrate and engage society in valuing the Amazon as a functional and integrated socioeconomic system, in which the benefits created by a bioeconomy in promoting peoples' well-being are clear. A co-benefit of a well-established bioeconomy system includes people enjoying food security and having equal access to healthy, sustainable, resilient, and contextually appropriate food systems. Attractive policies to create incentives (i.e., fiscal incentives) and engage the private sector and governments on investing in incubating innovation on forest/river-derived products is a fundamental step to consolidate this new economic perspective. Research and governance measures need to address and counterbalance the perverse outcomes of market-based interventions, such as social conflict, 'elite capture' of the income, weakened social organization, and inequality (e.g., Pokorny *et al.* 2012).

25.4.2.3 Promote job creation and capacity building for a bioeconomy adapted to the Amazon context

The establishment of an economy based on the utilization and conservation of biological resources, such as the bioeconomy of forest/rivers, is based on solid investment in science, technology, and innovation. The potential for job creation of this type of economy is an important economic and social indicator for a region such as the Amazon, in which the majority of the population is located in the urban centers. The efforts to take the concept of bioeconomy and apply it in and for the Amazon context can create opportunities for a new green sustainable industrial revolution. There is no unique bioeconomy. The concept is diverse by itself and accommodates distinct arrangements to produce, support local communities, and create jobs while providing incentives for healthy standing forests and flowing rivers (Coslovsky 2021). Thus, large-scale and small-scale bioeconomies work side by side, strengthening and modernizing the establishment of industries in the cities while supporting local production in rural areas, shortening the distance between the product, producer, and industry, and stimulating their relationship towards a shared Living Amazon Vision. For that, support for peoples' capacity building will be fundamental, from the product collectors to the industry workers. Results from that effort would pave the road for sustainable solutions, knowledge generation, and the creation of new products, processes and services, strengthening the connection between the urban and rural areas of the Amazon.

25.4.2.4 Invest in science, education, and the creation of transdisciplinary hubs and centers of excellence in bioeconomy technology in the Amazon

Although some of the potential solutions to Amazonia's socio-environmental sustainability are well known, many areas require further research. Some of the key knowledge gaps are related to the transition from destructive and exclusive to regenerative, equitable, and sustainable approaches to income generation. To accelerate and facilitate this transition, it is essential to have secure public and private investment in basic education and science, technology, and innovation for sustainable economic activities. Creating hubs and centers of excellence for bioeconomy technology in the Amazon and reconciling Indigenous and local knowledge with science and technology is fundamental to consolidating research on the biodiversity potential for medical, cosmetic, or food industries. These are just some of the investment mechanisms that can contribute to a bioeconomy that values forests, rivers, and peoples. Investment in regenerative practices will also be necessary given the scale of loss, change, and ecological degradation. These investments will potentially generate improvements in local education, the creation of more jobs, and the engagement of local communities in more diversified economies (see Chapter 30). The expansion of the açaí economy is one example (Peña-lévano *et al.* 2020). Additionally, eco-tourism in the Amazon and its chain can be leveraged, benefiting distinct stakeholders, from rural areas to urban centers (Medeiros and Young 2011). Furthermore, the environmental services provided by forests and rivers should be valued for all their potential, including the ability to store carbon, provide thermal comfort and clean water, and house biodiversity.

25.4.2.5 Invest in rural, urban, and periurban infrastructure that enables multiple Amazonian human groups to benefit from bioeconomy activities

To reach a scenario in which a bioeconomy is the backbone of the Amazon's economy, it is fundamental to have policies that also invest in sustainable infrastructure in urban and periurban areas so that urban Amazonian citizens can benefit from these assets stimulated by the bioeconomy. This economy will probably demand more energy supply, improved sanitation, and better roads. All this infrastructure needs to be realized following the principles and values of a Living Amazon, to support the establishment of a real bioeconomy era in the region, promoting increased public participation in infrastructure decision-making. The roads that support destructive farming and land speculation in the Amazon and that do not support sustainability are not part of this Vision.

25.4.2.6 Promote new rules for a regenerative financial system

The current exponential-growth-based money system will continue to "mortgage" and "indebt" nature, worsen inequality and corruption, and force Amazonian countries to seek perpetual capital growth beyond safe planetary boundaries. For a post-growth, steady-state economy to flourish, we must institute structural solutions that remove the impetus for perpetual capital growth such as credit instead of debt-based money systems, the institution of linear interest rather than compounded interest borrowing, and the promotion of local alternative currencies and systems of exchange. Financial health depends on the robust circulatory flow of money, accountability for externalities, re-localization of primary production and consumption, community-sourced capital, and financial incentives through pollution taxes, fines, and green subsidies to promote ecological and human well-being. Wealth must also be re-defined more holistically to include the biological productivity of ecosystems (IPBES 2019), as well as empowered community cooperation, resilience, and Indigenous and local knowledge. Policies and mechanisms for wealth redistribution are essential, such as wealth taxes on high-net-worth individuals and high-net-income corporations to fund universal or special function basic income, dignified livelihood guarantees, and basic services (e.g., health care, advanced education, housing), especially for rural, urban, and forest/river communities in the Amazon.

25.4.3 Strengthening Amazonian citizenship and governance

25.4.3.1 Implement a Bioregional and Biodiplomacy (environmental diplomacy) governance system to promote better natural resource management and strengthen human and territorial rights

Governance represents one of the major forces of sustainability. Equal opportunities for participation and representation in decision-making processes enhance socio-environmental connections and promote well-being (see Chapter 31). In the Living Amazon Vision, it is imperative that civil society institutions that represent the voices of the forest and rivers be strengthened and heard, creating strong Amazonian citizenship. To achieve this level of governance, some policies must be developed and strengthened, associated with innovative institutional and organizational structures and arrangements. These policies must derive from a governance system that incorporates elements beyond political boundaries and considers "bioregional domains" (i.e., Basin-level governance structures). This requires a type of "biodiplomacy" in which Pan-Amazonian countries and their governance structures have improved mechanisms to interact and articulate transnational strategies and programs to promote better natural resource management and strengthen territorial rights.

25.4.3.2 Promote the recognition of different identities, knowledge systems, and rights

The recognition and value of distinct cultures and identities and their contribution to conservation is essential to support and empower IPLCs and promote social justice. Strong government institutions that work to support and implement IPLC policies need to be in place in Amazonian countries to connect pledges by IPLCs with effective public policies that promote territorial security and human rights. Partnership to support IPLC organizations and articulation among them is also fundamental. Strong IPLC movements are fundamental to pressure for better policy implementation and recognition of its importance by society (see Chapter 31).

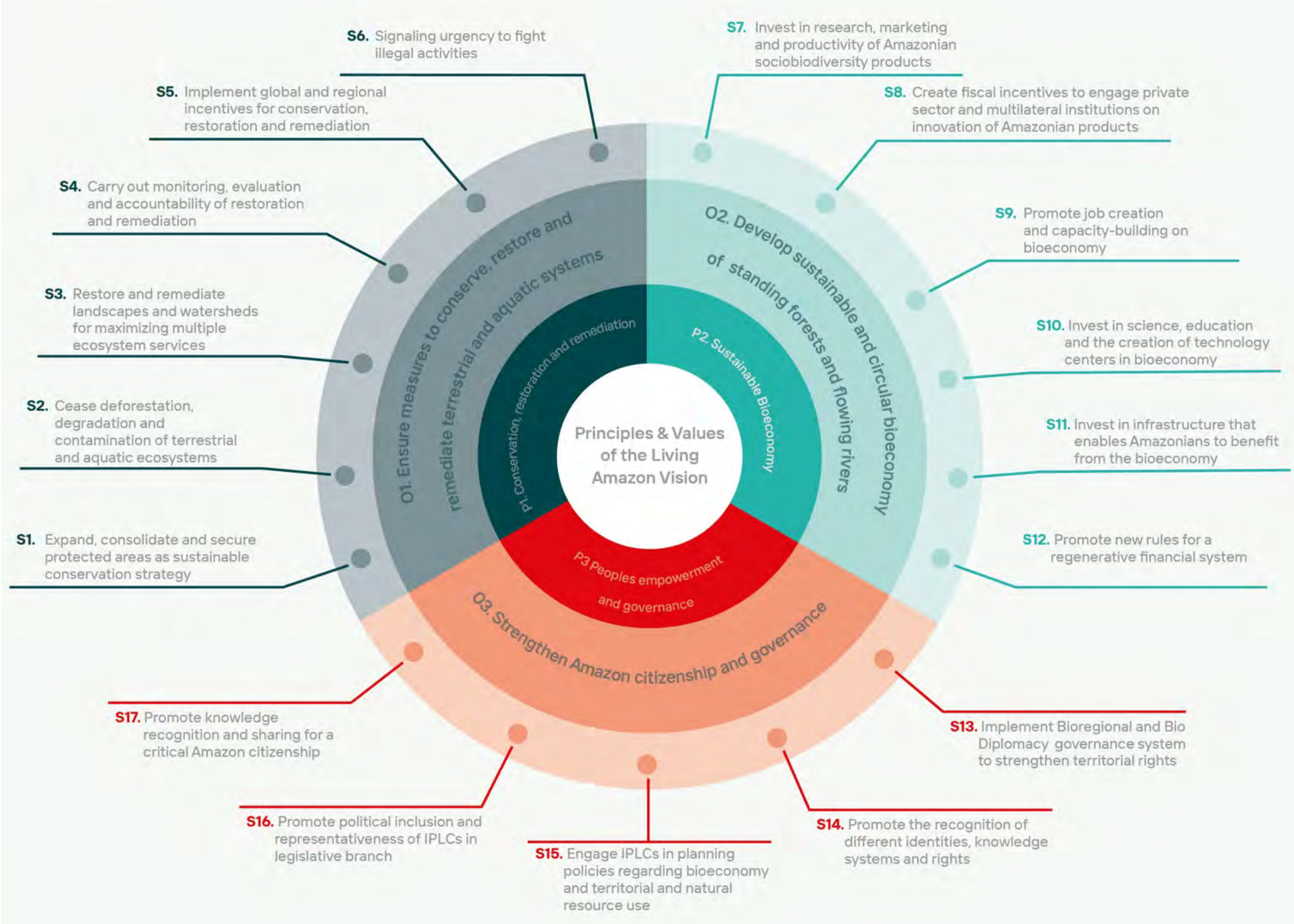


Figure 25.5 Main pillars (P), objectives (O), and strategies (S) for a living Amazon Vision.

25.4.3.3 Engage and consult IPLCs when planning policies regarding bioeconomy arrangements and the use of territories and natural resources

Among all policies, the ones that improve territorial governance and value knowledge and traditional cultures shared by different segments of society envisaged by sustainability policies are primordial. Some examples include participatory planning for rural (i.e., forest and non-forest, river basins) and urban areas (infrastructure planning), the incorporation of Indigenous territorial plans and policies, including policies to support Indigenous and local languages, in national development plans, and programs that support consolidation and co-management of protected areas and their forest and water resources (i.e., ARPA; Amazon Sustainable Landscapes Program - ASL; National Policy on Territorial and Environmental Management in Indigenous Lands - PNGATI).

25.4.3.4. Promote political inclusion and representation of IPLCs in the legislative branch and enhance decision-making capacity in public policy

Some elements need to be included to reach the level of citizenship that values healthy standing forests and flowing rivers in rural and urban areas, such as inclusive governance, which accounts for democratic participation of minorities, mainly those directly dependent on natural resources (e.g., IPLCs). Therefore, the enhancement of the decision-making capacity in public policies by minorities such as IPLCs' representatives with quotas in the legislative branch, associated with the development of broad communication strategies, are important tools to engage society in recognizing and respecting the rights, identities and knowledge of IPLCs.

25.4.3.5 Promote intercultural education, and knowledge recognition and sharing for a critical Amazon citizenship

The recognition of ancient and empirical knowledge and its role in conservation is an important principle of the Living Amazon (see section 3.6). Therefore, policies that value and secure these knowledge rights are a fundamental part of strengthening governance in the Amazon. In addition, democratic education, such as locally appropriate education curricula, to support a culture of innovation at different scales, increased capacity building for Indigenous peoples and local communities, and knowledge recognition and sharing between IPLCs and other groups of society for the construction of active and critical Amazonian citizenship, are paramount (see Chapters 32 and 33).

The transition to a Living Amazon Vision is not trivial. It requires the establishment of a set of feasible solutions supported by political will, civil society, and private engagement (Figure 25.6). It is further envisaged that establishment of the three pillars will result in eight related outcomes, namely: (i) Improved science and knowledge production and communication characterized by significant improvement in the efficiency of resource utilization, and in finding new development practices, resources, and alternatives, as well as the formulation and selection of sustainable development policies in the decision-making processes at different levels; (ii) More evidence-based decision-making that will rationalize and legitimize public policies and measures that contextualize natural resource utilization and sustainable human development and apply across a broad range of communities and among various populations; (iii) Market equity that ensures a fair distribution of cost and benefits of sustainable resource use and economic development across different scales; (iv) Improved livelihoods and well-being to the extent that Amazonian inhabitants have the ability to live lives that they value, including their cultural heritage, health, access to land and natural resources, and importantly, income-generating opportunities; (v) IPLCs' territorial rights that will protect their land, safeguard biocultural diversity and nature's contributions to their well-being; (vi) Healthier environments that will, in turn, sustain the health and well-being of humans across temporal and geographical scales; (vii) Green urban economies decoupled from extractive activities, which will provide greater scope for Amazonian cities to become highly innovative areas of economic prosperity;

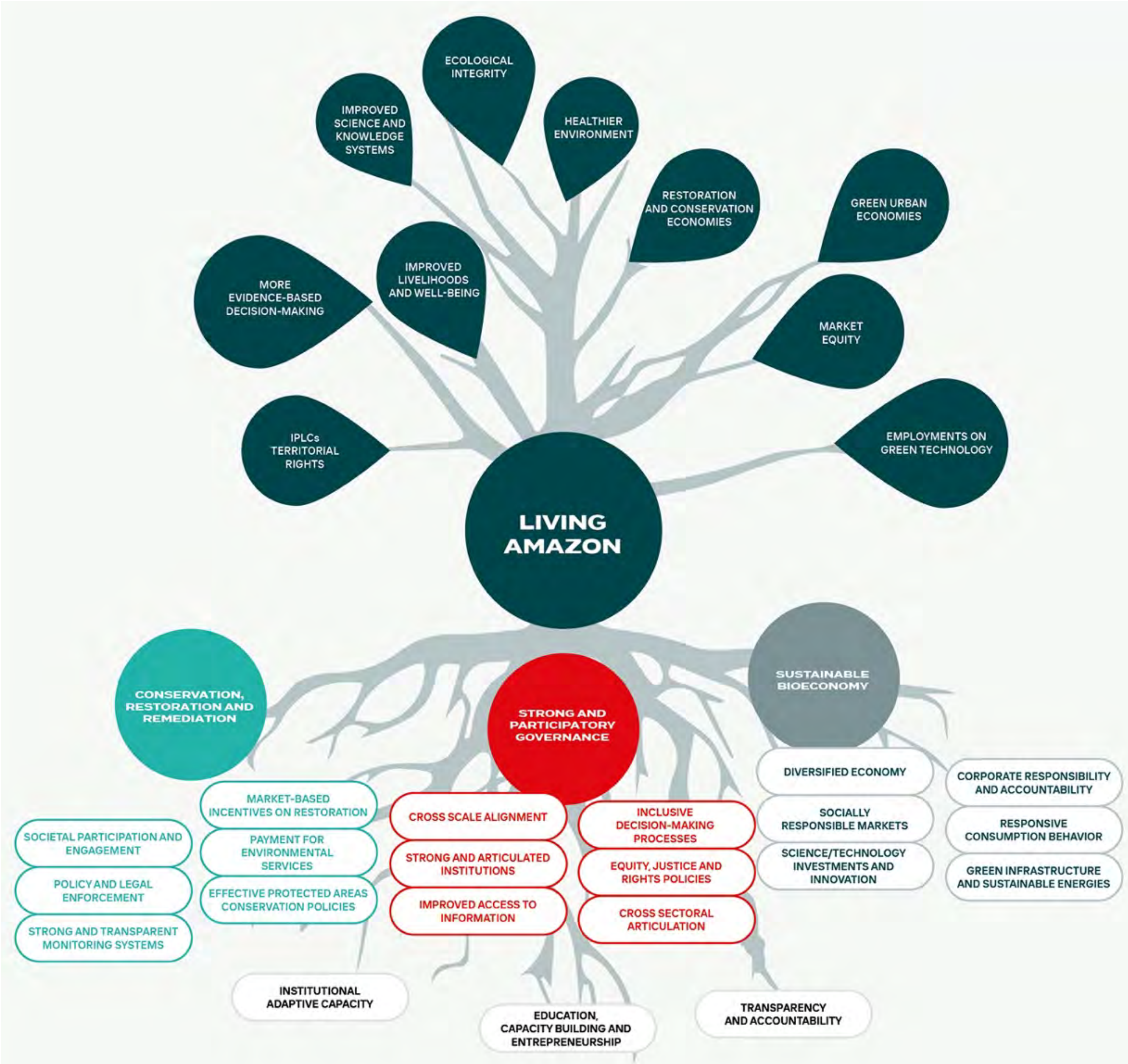


Figure 25.6 The Living Amazon solution tree

prosperity; (viii) Employments in green technology, which will ultimately become the emblem of a more sustainable and low carbon, climate resilient Amazonian economy and society, and will ensure the protection of the environment, with the conservation of natural resources for present and future generations.

Finally, we are seeing increasing alignment between Indigenous worldviews and philosophies of Living Earth, Mother Earth, kinship with all life, and the emerging Earth Systems scientific paradigms of seeing the Amazon as a key entity of the biosphere's hydro-climatic system and the purveyor of atmospheric rivers, a mediator of carbon, and a bulwark against extinction. Redefining true wealth as healthy standing forests and flowing rivers is a promising framework for thinking forward and co-developing a life-centric economy.

The COVID-19 pandemic and our global ecological crises are giving rise to the frameworks of "One health" "planetary health", "well-being", and "living economies" in the new climate regimes that protect the foundations of life on Earth in contrast to the dominant accumulation ideologies and market economics, in which life is valued only insofar as it produces financial returns and where growth in assets is the primary focus and measure of "prosperity" and, currently, primarily derived from the depletion of Earth's biological productivity. The responsibility for materializing the Living Amazon goes beyond the Pan Amazonian countries, it is a call to engage all governments and human beings in sustaining life in all forms.

25.5 Conclusions

There are several worldviews in the Amazon, which represent the diversity of social actors that have distinct needs and strategies and use and interact with the region's natural resources. The complexity and often opposing or conflicting worldviews, values, and principles impose barriers to establishing a consensus among Amazon sustainability and the consolidation of a shared vision for the future of the region. However, one can argue that there are elements that can be used to guide this diversity of views towards a healthier, prosperous, and equitable future. These elements are expressed in principles and values that are fundamental to support the pillars of a new future vision for the Amazon.

These principles and values include recognition of the ecological, biological, and cultural diversity, as well as the heterogeneity of Amazonian landscapes as a product of their long history of geological formation and human/nature interactions. It also recognizes the fundamental role of this geodiversity in providing ecosystems services and functions, which are vital to support life and local, regional, and global climate. It incorporates the idea that everything is integrated and interconnected from ecological, to economic and socio-cultural systems, where significant disturbances in one can provoke cascade changes in the other. These interconnections include the relationship between urban and rural areas and how Amazon cities can become hubs of sustainability and innovation, which can percolate and positively influence natural resource use in rural areas. It assumes a strong and inclusive level of governance, in which the capacity to engage and promote democratic participation in decision-making processes is strengthened. Lastly, the rights of IPLCs and respect for their cultures, knowledge, traditions, and beliefs are recognized and valued. If these principles and values are recognized and followed, it is likely that the future of a Living Amazon can be materialized, providing benefits to all living beings, including prosperous and inclusive economic activities, ecological integrity and diversity, and social justice and rights.
Here, we envision the future of the Amazon based on three central pillars and strategies intrinsically oriented by the Living Amazon principles and values. These pillars include (i) conservation, restoration, and remediation strategies, (ii) the promotion of a sustainable bioeconomy of forest and rivers, and (iii) the empowerment of peoples and governance. These three pillars offer a set of recommendations based on arguments presented over Parts I and II of this report and detailed in the chapters of Part III.

The Living Amazon Vision for the region represents an opportunity to lead the world by example, recognizing the intrinsic value of nature, culture, and peoples to development and breaking the dichotomy between conservation and aspirations for human well-being.

25.6 Recommendations

- Develop and implement transboundary Amazon restoration and conservation plans that support landscape-level conservation initiatives for forest and rivers and take into consideration levels of priority and risk areas to maintain connectivity and the health of freshwater ecosystems, ecological functions, and conserve and restore the heterogeneous biomes and their biodiversity;

- Create innovative financial incentives for conservation and restoration, as well as more investment in science and technology to support studies and research collaborations to fill the knowledge gap on biodiversity and its potential to support life;
- Strengthen the management, economies, and governance of protected areas and flowing rivers, as well as their perception to society as a source of cross-scale ecological, economic, and social co-benefits;
- Structure regional innovation bioeconomy hubs aimed at economies that sustain life in the Amazon Basin, connecting rural producers and IPLCs with science and technology centers in urban areas, facilitating the ethical production and dissemination of knowledge and sustainable goods;
- Provide democratic connectivity and internet access and invest in sustainable and green infrastructure as a way to support equal opportunities and promote diversified and digital economies, education, and inclusive and participatory governance strategies;
- Improve governance, transparency, and accountability (e.g., democratic access to monitoring tools), and support enforcement policies and market engagement in good practices to prevent illegal deforestation and associated activities and reduce all causes of anthropogenic forest conversion, pollution, and degradation;
- Support the adaptive capacities of institutions in terms of people, infrastructure, and financial support towards more modernized and interconnected governance procedures that support better management and facilitate collaborative and decentralized monitoring of natural resources;
- Strengthen and enforce international agreements, national laws and constitutions, and other mechanisms to ensure the promotion of sustainable production and the rights of IPLCs;
- Promote and support the participation of IPLCs in the design and implementation of conservation and development policies across the Amazon, and recognize Indigenous Life Plans, Consultancy Protocols, and other initiatives as legitimate instruments of planning and territorial monitoring, while guaranteeing the rights of Indigenous peoples, Afro-descendant communities, and other local communities to prior consultation and full participation in planning and implementation of development initiatives;
- Support the recognition and protection of land, rivers, and territorial rights of IPLCs, including the ones in voluntary isolation, in connection to policies that value and support land, forest- and water-based livelihoods, including economic incentives and credit for non-timber forest products.

Although this list is extensive, it summarizes the main pathways to achieve a Living Amazon in the next three decades, avoiding the over-exploitation of the natural resources, disruption of ecosystem functions, increase of inequalities, poverty, and cultural (especially linguistic) and biodiversity extinction. All of these recommendations embedded in the Living Amazon Vision are in alignment with the 2030 Agenda and the SDGs that face distinct levels of implementation in the Amazon and are presented in the following chapter.

25.7 References

Ahlström A, Canadell JG, Schurgers G, *et al*. 2017. Hydrologic resilience and Amazon productivity. *Nature Communications* **8**:1–9.

Alencar A, Nepstad D, Mendoza E, *et al*. 2012. Acre State' s Progress Towards Jurisdictional REDD: Research, Analysis, and Recommendations for the State Carbon Incentive Program (ISA-Carbono). Instituto de Pesquisa Ambiental da Amazônia, Brasília, DF, 53p.

Alencar A, Castro I, Laureto L, *et al*. 2021. Amazônia em Chamas - Desmatamento e fogo nas florestas públicas não destinadas: Nota técnica nº 7. Brasília, DF: Instituto de Pesquisa Ambiental da Amazônia. Available at: https://ipam.org.br/bibliotecas/amazonia-em-chamas-7-desmatamento-e-fogo-nas-florestas-publicas-nao- -destinadas/.

Alvez-Valles CM, Balslev H, Carvalho FA, *et al*. 2018. Endemism and conservation of Amazon palms. *Biodiversity and Conservation* **27**:765–784.

Alvim R, Regina C, Futemma T, and Queiroz H. 2020. Indigenous territories and governance of forest restoration in the Xingu River Land Use Policy Indigenous territories and governance of forest restoration in the Xingu River (Brazil). Land Use Policy:104755.

Angelsen A and Wertz-Kanounnikoff S. 2008. Moving ahead with REDD. Issues, options and implications. Bogor.

Aragão LEOC, Anderson LO, Fonseca MG, *et al*. 2018. 21st Century drought-related fires counteract the decline of Amazon deforestation carbon emissions. *Nature Communications* **9**:1–12.

Assunção J, Gandour C, Rocha R, and Rocha R. 2013. Does Credit Affect Deforestation? Evidence from a Rural Credit Policy in the Brazilian Amazon. *Climate Policy Initiative*: 50.

Athayde S, Stepp JR, and Ballester WC. 2016. Engaging Indigenous and academic knowledge on bees in the Amazon: Implications for environmental management and transdisciplinary research. *J. Ethnobiol. Ethnomed*. **12**: 1–19.

Bacci ML. 2010. El Dorado in the Marshes: Gold, Slaves and Souls Between the Andes and the Amazon. Polity Press, MA, USA.

Baccini A, Goetz SJ, Walker WS, *et al*. 2012. Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. *Nature Climate Change* **2**:182–185.

Baker JCA and Spracklen DV. 2019. Climate Benefits of Intact Amazon Forests and the Biophysical Consequences of Disturbance. *Frontiers in Forests and Global Change* **2**:1–13.

Bebbington A. 2013. Underground Political Ecologies. *Peripherie, Zeitschrift für politik und Ökonomie in der Dritten Welt* **33**:402–424.

Becker BK. 2004. Amazônia - Geopolítica na Virada do III Milênio. Editora Garamond, Ed. Rio de Janeiro.

Beer C, Reichstein M, Tomelleri E, *et al*. 2010. Terrestrial gross carbon dioxide uptake: Global distribution and covariation with climate. *Science* **329**:834–838.

Biedenweg K, Stiles K, and Wellman K. 2016. A holistic framework for identifying human wellbeing indicators for marine policy. Marine Policy 64:31–37.

Biery-Hamilton GM. 2002. Conflicting resource values: Caboclos. Research in Economic Anthropology 21. Emerald Group Publishing Limited.

Börner J, Schulz D, Wunder S, and Pfaff A. 2020. The effectiveness of forest conservation policies and programs. *Annual Review of Resource Economics* **12**:45–64.

Brienen RJW, Phillips OL, Feldpausch TR, *et al*. 2015. Long-term decline of the Amazon carbon sink. *Nature* **519**: 344–8.

Bullock EL, Woodcock CE, Souza C, and Olofsson P. 2020. Satellite-based estimates reveal widespread forest degradation in the Amazon. *Global Change Biology* **26**:2956–2969.

Buschbacher R, Athayde S, Bartels WL, and Mello R. 2016. Avaliação da Resiliência como ferramenta para entender a fronteira amazônica como um sistema socioecológico. *Sustentabilidade em Debate* **7**:36–52.

Castello L, Mcgrath DG, Hess LL, *et al*. 2013. The vulnerability of Amazon freshwater ecosystems. *Conservation Letters* **6**:217–229.

Chambouleyron R and Ibáñez-Bonillo P. 2019. The Colonial Amazon. Page Oxford Research Encyclopedia of Latin American History.

CIFOR. 2018. CIFOR Letter to Governor Edmund Brown "Support for the California Tropical Forest Standard." Available at: www.arb.ca.gov/lispub/comm/bccomdisp.php?listname=tfs2018&comment_num=24&virt_num=21.

Correa J, Van der Hoff R, and Rajão R. 2019. Amazon fund 10 years later: Lessons from the world's largest REDD+ program. *Forests* **10**:1–20.

Costa S and Brondízio E. 2011. Cities Along the Floodplain of the Brazilian Amazon: Characteristics and Trends. In: Pinedo-Vasquez M, Ruffino M, Padoch C, Brondízio E. (Eds) The Amazon Várzea. Springer, Dordrecht.

Coslovsky S. 2021. Oportunidades para exportação de produtos compatíveis com a floresta na Amazônia brasileira. Amazônia 2030. Available in: https://amazonia2030.org.br/wp-content/uploads/2021/04/AMZ2030-Oportunidades-para-Exportacao-de-Produtos-Compativeis-com-a-Floresta-na-Amazonia-Brasileira-1-2.pdf

Curtis PG, Slay CM, Harris NL, *et al*. 2018. Classifying drivers of global forest loss. *Science* **361**:1108–1111.

Dala-Corte RB, Melo AS, Siqueira T, *et al*. 2020. Thresholds of freshwater biodiversity in response to riparian vegetation loss in the Neotropical region. *Journal of Applied Ecology* **57**:1391–1402.

Duchelle AE, Seymour F, Brockhaus M, *et al*. 2019. Forest-Based Climate Mitigation: Lessons from REDD+ Implementation. World Resources Institute.

Fleuri RM and Fleuri LJ. 2018. Learning from Brazilian Indigenous Peoples: Towards a Decolonial Education. *Australian Journal of Indigenous Education* **47**:8–18.

Folke C. 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change* **16**:253–267.

Frey GP, West TAP, Hickler T, *et al*. 2018. Simulated impacts of soy and infrastructure expansion in the Brazilian Amazon: A maximum entropy approach. *Forests* **9**:1–23.

García Rodríguez E, de Doens LC, Palao RGG, *et al*. 2015. Andean Biotrade. Innovative Answers and Sustainable Solutions for Local Development in Latin America. Caracas: CAF. Available at: http://scioteca.caf.com/handle/123456789/1500

Gardner TA, Benzie M, Börner J, *et al*. 2019. Transparency and sustainability in global commodity supply chains. *World Development* **121**:163–177.

Gatti LV, Basso LS, Miller JB, *et al*. 2021. Amazonia as a carbon source linked to deforestation and climate change. *Nature* **595**:388–393.

GCF Task Force. 2014. Rio Branco Declaration. Available at: https://www.gcftf.org/post/rio-branco-declaration.

Giudice R, Börner J, Wunder S, and Cisneros E. 2019. Selection biases and spillovers from collective conservation incentives in the Peruvian Amazon. *Environmental Research Letters* **14**.

Global Footprint Network. 2018. Global Footprint Network. Oakland, CA, USA.
Gonzalez J. 2021. European public roundly rejects Brazil trade deal unless Amazon protected. Mongabay. US.
Griscom BW, Busch J, Cook-Patton SC, *et al*. 2020. National mitigation potential from natural climate solutions in the tropics. *Philosophical Transactions of the Royal Society B: Biological Sciences* **375**.
Guimberteau M, Ciais P, Pablo Boisier J, *et al*. 2017. Impacts of future deforestation and climate change on the hydrology of the Amazon Basin: A multi-model analysis with a new set of land-cover change scenarios. *Hydrology and Earth System Sciences* **21**:1455–1475.
Hecht S and Cockburn A. 1990. The fate of the forest: developers, destroyers and defenders of the Amazon. Harper Perennial, New York.
Hickel J. 2018. Better technology isn't the solution to ecological collapse. Fast Company. Published on March 26, 2018. Available at: https://www.fastcompany.com/40548564/better-technology-isnt-the-solution-to-ecological-collapse
Hilker T, Lyapustin AI, Tucker CJ, *et al*. 2014. Vegetation dynamics and rainfall sensitivity of the Amazon*. Proceedings of the National Academy of Sciences of the United States of America* **111**:16041–16046.
Himes A and Muraca B. 2018. Relational values: the key to pluralistic valuation of ecosystem services. *Current Opinion in Environmental Sustainability* **35**:1–7.
Hirons M, Comberti C, and Dunford R. 2016. Valuing Cultural Ecosystem Services. *Annual Review of Environment and Resources* **41**:545–574.
Hoelle J. 2017. Jungle beef: Consumption, production and destruction, and the development process in the Brazilian Amazon. *Journal of Political Ecology* **24**:743–762.
Huambachano M and Cooper L. 2020. Values, Knowledge, and Rights Shaping Land Use in the Peruvian Amazon. *Case Studies in the Environment* **4**:1–14.
International Database on REDD+ projects and programs. Available at: https://www.reddprojectsdatabase.org/
Ioris AAR. 2015. Theorizing state-environment relationships: Antinomies of flexibility and legitimacy. *Progress in Human Geography* **39**:167–184.
Ioris AAR. 2020. Revisiting frontier theory and the experience of frontier-making. In: Ioris RF and Shubin S, editors. Frontiers of Development in the Amazon: Riches, Risks and Resistances. Lexington Books, London.
IPBES. 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Brondizio ES, Settele J, Díaz S, and Ngo HT (editors). IPBES secretariat, Bonn, Germany. 1148 pages.
Iriarte J, Elliott S, Maezumi SY, *et al*. 2020. The origins of Amazonian landscapes: Plant cultivation, domestication and the spread of food production in tropical South America. *Quaternary Science Reviews* **248**:106582.
IWGIA. 2020. The Indigenous World 2020.
Jézéquel C, Tedesco PA, Darwall W, *et al*. 2020. Freshwater fish diversity hotspots for conservation priorities in the Amazon Basin. *Conservation Biology* **34**:956–965.
Jones CI. 2016. The Facts of Economic Growth. (Eds.) Taylor JB, Uhlig H. Handbook of Macroeconomics, Elsevier 2: Pages 3-6
Kawsak Sacha Declaration. 2018. Kawsak Sacha Declaration. Available at: https://kawsaksacha.org/.
de Koning F, Aguiñaga M, Bravo M, *et al*. 2011. Bridging the gap between forest conservation and poverty alleviation: The Ecuadorian Socio Bosque program. *Environmental Science and Policy* **14**:531–542.
Kroner REG, Qin S, Cook CN, *et al*. 2019. The uncertain future of protected lands and waters*. Science* **364**(6443):881–886.
Kull M, Pyysiäinen J, Christo G, and Christopoulos S. 2018. Making sense of multilevel governance and governance coordination in Brazil: The case of the Bolsa Verde Programme*. Regional & Federal Studies* **28**:47–78.
Laing T. 2018. Guyanaas REDD+ Agreement with Norway: Perceptions of and Impacts on Indigenous Communities. *SSRN Electronic Journa*l.
Latrubesse EM, Arima EY, Dunne T, *et al*. 2017. Damming the rivers of the Amazon basin. *Nature* **546**:363–369.
Lea VR. 2017. Ontological Conflicts Concerning Indigenous Peoples in Contemporary Brazil. *ab-Original* **1**(2):151–175.
Lima PGC, Coelho–Ferreira M, and da Silva Santos R. 2016. Perspectives on Medicinal Plants in Public Markets across the Amazon: A Review. *Economic Botany* **70**:64–78.
Lin D, Hanscom L, Murthy A, *et al*. 2018. Ecological footprint accounting for countries: Updates and results of the national footprint accounts, 2012-2018. *Resources* **7**:2012–2018.
Lovejoy TE and Nobre C. 2018. Amazon Tipping Point. *Science Advances* 4:eaat2340.
Lovejoy TE and Nobre C. 2019. Amazon Tipping Point: Last chance for action. *Science Advances* **5**(12): eaba2949. Doi: 10.1126/sciadv.aba2949.
Mapbiomas. 2020. Mapbiomas Amazonia. Available at: https://amazonia.mapbiomas.org/.
McSweeney K, Richani N, Pearson Z, *et al*. 2017. Why Do Narcos Invest in Rural Land? *Journal of Latin American Geography* **16**:3–29.
Medeiros R and Young CEF. 2011. Contribuição das unidades de conservação brasileiras para a economia nacional. UNEP-WMCM, Brasilia.
Millenium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: synthesis. Island press, Washington, DC.
Moutinho P, Stella O, Lima A, *et al*. 2011. REDD in Brazil: A focus on the Amazon. IPAM - Instituto de Pesquisa Ambiental da Amazônia, Brasília, DF.
Müller-Hansen F, Heitzig J, Donges JF, *et al*. 2019. Can Intensification of Cattle Ranching Reduce Deforestation in the Amazon? Insights From an Agent-based Social-Ecological Model. *Ecological Economics* **159**:198–211.
Nepstad D, McGrath D, Stickler C, *et al*. 2014. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* **344**:1118–23.
Nepstad D, Schwartzman S, Bamberger B, *et al*. 2006. Inhibition of Amazon deforestation and fire by parks and indigenous lands. *Conservation Biology* **20**:65–73.

Nesha MK, Herold M, de Sy V, *et al*. 2021. An assessment of data sources, data quality and changes in national forest monitoring capacities in the Global Forest Resources Assessment 2005-2020. *Environmental Research Letters* **16**(5).

Nesshöver C, Assmuth T, Irvine KN, *et al*. 2017. The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Science of the Total Environment* **579**:1215–1227.

Nolte C, Agrawal A, Silvius KM, and Soares-Filho BS. 2013. Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. *Proceedings of the National Academy of Sciences* **110**:4956–4961.

van Norren DE. 2020. The Sustainable Development Goals viewed through Gross National Happiness, Ubuntu, and Buen Vivir. *International Environmental Agreements: Politics, Law and Economics* **20**:431–458.

Olsson E. 2011. The Value of Knowledge. *Philosophy Compass* **6**:874–883.

Opperman JJ, Shahbol N, Maynard J, *et al*. 2021. Safeguarding free-flowing rivers: The global extent of free-flowing rivers in protected areas. *Sustainability* (Switzerland) **13**:1–18.

Padoch C, Brondizio E, Costa S, *et al*. 2008. Urban forest and Rural Cities: Multi-sited Households, Consumption Patterns, and Forest Resources in Amazonia. *Ecology and Society* **13**:278–282.

Peña-lévano L, Adams C, and Burney S. 2020. Latin America' s Superfood Economy: Producing and Marketing Açaí, Chia Seeds, and Maca Root. *Choices* **35**:3–8.

Pokorny B, Johnson J, Medina G, and Hoch L. 2012. Market-based conservation of the Amazonian forests: Revisiting win-win expectations. *Geoforum* **43**:387–401.

RAISG. 2020. Amazônia sob pressão. São Paulo.

Redparques. 2019. Visión Amazónica: Integración de las Áreas Protegi- das del Bioma Amazónico – IAPA. Resultados y aprendizajes (2014- 2019). Proyecto IAPA – Visión Amazónica. Unión Europea, WWF, FAO, UICN, ONU Medio Ambiente. Bogotá, Colombia.

Roitman I, Vieira LCG, Jacobson TKB, *et al*. 2018. Rural Environmental Registry: An innovative model for land-use and environmental policies. *Land Use Policy* **76**:95–102.

Sakschewski B, Von Bloh W, Boit A, *et al*. 2016. Resilience of Amazon forests emerges from plant trait diversity. *Nature Climate Change* **6**:1032–1036.

Salmón E. 2000. Kincentric Ecology: Indigenous Perceptions of the Human – Nature Relationship. *Ecol. Appl.* **10**: 1327–1332.

Sauer S. 2018. Soy expansion into the agricultural frontiers of the Brazilian Amazon: The agribusiness economy and its social and environmental conflicts. *Land Use Policy* **79**:326–338.

Schönenberg R. 2019. Collateral Damage of Global Governance on the Local Level: An Analysis of Fragmented International Regimes in the Brazilian Amazon. In: Polese A, Russo A, Strazzari F. (Eds.), Governance Beyond the Law: The Immoral, The Illegal, The Criminal. Springer International Publishing.

Schmink M. 2014. Forest Citizenship in Acre, Brazil. In: Forest under pressure - Local Responses to Global Issues. IUFRO Worl. International Union of Forest Research Organizations (IUFRO).

Schmink M and Wood CH. 1992. Contested Frontier in Amazonia. Columbia University Press, New York.

SDSN-A. 2021. SDSN-A Platform. SDSA Amazônia. Available at: http://maps.sdsn-amazonia.org/

Seymour F and Busch J. 2016. Why Forests Why Now? The Science, Economics, and Politics of Tropical Forests and Climate Change. Washington, DC: Center for Global Development.

Simonet G, Subervie J, Ezzine-De-Blas D, *et al*. 2019. Effectiveness of a REDD+ project in reducing deforestation in the Brazilian Amazon. *American Journal of Agricultural Economics* **101**(1):211–229.

Smith CC, Healey JR, Berenguer E, *et al*. 2021. Old-growth forest loss and secondary forest recovery across Amazonian countries. *Environmental Research Letters* **16**.

Soares-Filho B and Rajão R. 2018. Traditional conservation strategies still the best option. *Nature Sustainability* **1**:608–610.

Sombroek W. 2000. Amazon landforms and soils in relation to biological diversity. *Acta Amazonica* **30**:81–81.

de Souza DO and Alvalá RCS. 2014. Observational evidence of the urban heat island of Manaus City, Brazil. *Meteorological Applications* **21**:186–193.

Souza ML and Alencar A. 2020. Assentamentos Sustentáveis na Amazônia: Agricultura Familiar e Sustentabilidade Ambiental na maior floresta tropical do mundo. IPAM - Instituto de Pesquisa Ambiental da Amazônia, Brasília, DF.

Stabile MCC, Guimarães AL, Silva DS, *et al*. 2020. Solving Brazil's land use puzzle: Increasing production and slowing Amazon deforestation. *Land Use Policy* **91**.

ter Steege H, Prado PI, Lima RAF, *et al*. 2020. Biased-corrected richness estimates for the Amazonian tree flora. *Scientific Reports* **10**:1–13.

ter Steege H, Vaessen RW, Cárdenas-López D, *et al*. 2016. The discovery of the Amazonian tree flora with an updated checklist of all known tree taxa. *Scientific Reports* **6**:1–15.

Thaler GM, Viana C, and Toni F. 2019. From frontier governance to governance frontier: The political geography of Brazil's Amazon transition. *World Development* **114**:59–72.

Turubanova S, Potapov PV, Tyukavina A, and Hansen MC. 2018. Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia. *Environmental Research Letters* **13**.

Valli M, Russo HM, and Bolzani VS. 2018. The potential contribution of the natural products from Brazilian biodiversity to bioeconomy. *Anais da Academia Brasileira de Ciencias* **90**:763–778.

Villén-Pérez S, Moutinho P, Nóbrega CC, and de Marco P. 2020. Brazilian Amazon gold: Indigenous land rights under risk. *Elementa: Science of the Anthropocene* **8**.

de Waroux YP, Garrett RD, Graesser J, *et al*. 2019. The Restructuring of South American Soy and Beef Production and Trade Under Changing Environmental Regulations. *World Development* **121**:188–202.

Williford B. 2018. JBuen Vivir as a Policy: Challenging Neoliberalism or Consolidating State Power in Ecuador. *Journal of World-Systems Research* **24**(1):96–122.

Wittmann F, Schöngart J, Montero JC, *et al*. 2006. Tree species composition and diversity gradients in white-water forests across the Amazon Basin. *Journal of Biogeography* **33**:1334–1347.
Wong GY, Luttrell C, Loft L, *et al*. 2019. Narratives in REDD+ benefit sharing: examining evidence within and beyond the forest sector. *Climate Policy* **19**:1038–1051.
Woodward D. 2015. Incrementum ad Absurdum: Global Growth, Inequality and Poverty Eradication in a Carbon-Constrained World. *World Economic Review*:43–62.
Zycherman A. 2016. Cultures of soy and cattle in the context of reduced deforestation and agricultural intensification in the Brazilian amazon. E*nvironment and Society: Advances in Research* **7**:71–88.

Amazon Assessment Report 2021

Chapter 26

Sustainable Development Goals (SDGs) and the Amazon

Foto: Ana Mendes/Amazônia Real

INDEX

GRAPHICAL ABSTRACT **2**

KEY MESSAGES **3**

ABSTRACT **3**

26.1 INTRODUCTION **4**

26.2 EVALUATION OF RELEVANCE AND LIMITATIONS OF DEFINITIONS OF SUSTAINABLE DEVELOPMENT IN THE AMAZON **6**

26.2.1 PEOPLE 6
26.2.1.1 What are the limitations of the definition of poverty in the Amazon? *8*
26.2.1.2 Natural and Cultural Capital: Rethinking sustainable 'livelihoods' *9*
26.2.1.3 Ethnic and gender disparities in the Amazon *10*
26.2.2 PLANET 11
26.2.2.1 SDG 6: Clean Water *11*
26.2.2.2 SDG 12: Responsible Production and Consumption *14*
26.2.2.3 SDG 13: Urgent Action to Combat Climate Change *15*
26.2.2.4 SDG 15: Life on Land *17*
26.2.3 PROSPERITY 18
26.2.4 PEACE 21
26.2.4.1 Environmental justice, human rights and peace in the Amazon *21*
26.2.5 PARTNERSHIPS 22

26.3 CONCLUSIONS **24**

26.4 RECOMMENDATIONS **26**

26.5 REFERENCES **26**

Graphical Abstract

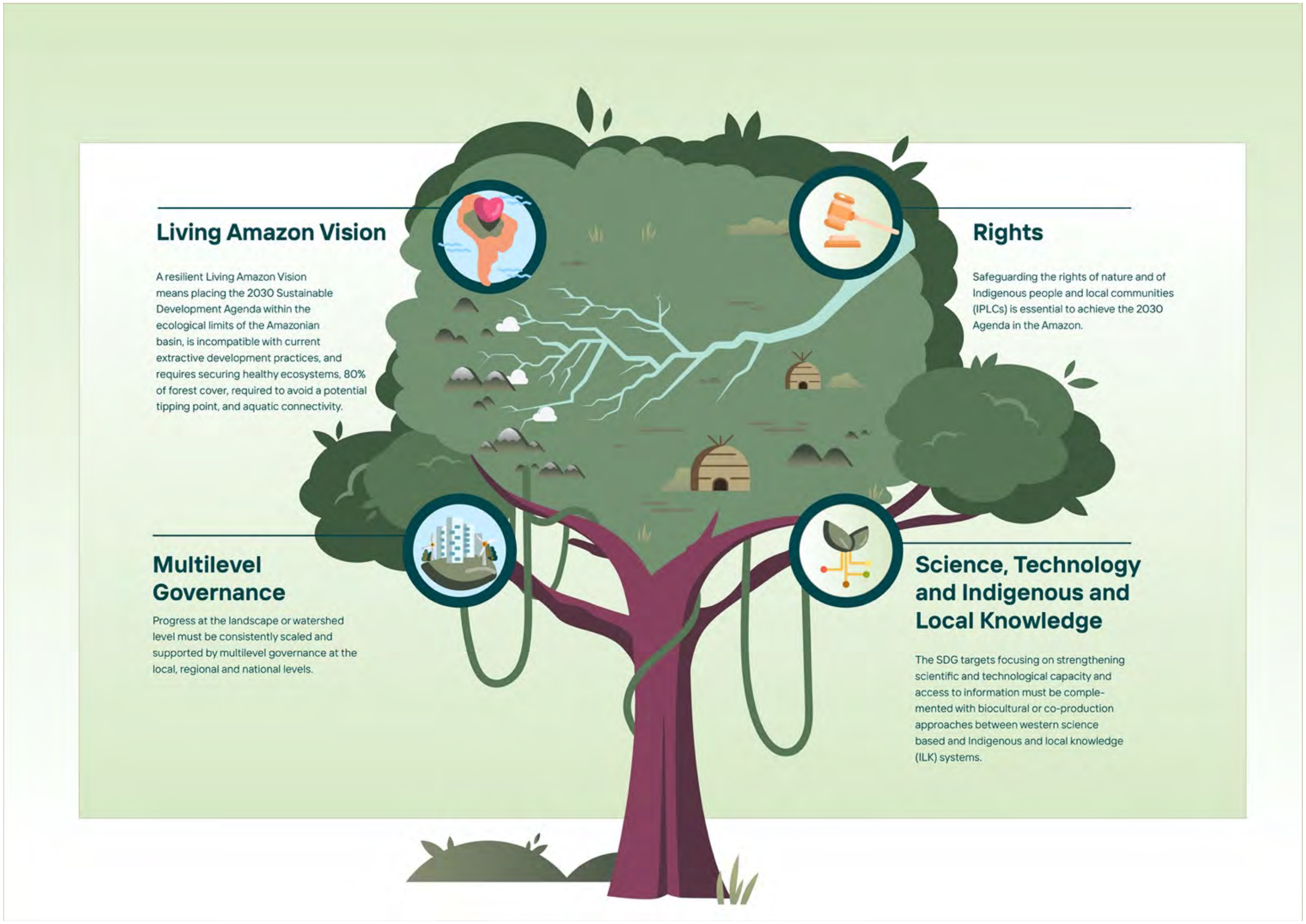


Figure 26.A A resilient Living Amazon Vision means placing the Sustainable Development Agenda within the limits of the Amazonian basin, safeguarding the rights of Indigenous peoples and local communitites, investing in science, technology and inclusive knowledge systems, while supported by multilateral governance at the local, regional, and national levels.

Sustainable Development Goals (SDGs) and the Amazon

Lilian Painter[a], Ane Alencar[b] Aoife Bennett[c], Paulette Bynoe[d], Camilo Guio[e], Maria R. Murmis[f], Belen Paez[g], Daniel Robison[h], Martin von Hildebrand[i], Valeria Ochoa-Herrera[j,k], Isabella Leite Lucas[l]*

Key Messages

- A resilient Living Amazon Vision means placing the People, Prosperity, Peace, and Partnership dimensions of the 2030 Agenda within the ecological limits to disturbance of the Amazonian Basin.
- The Living Amazon Vision is incompatible with current extractive development practices and requires securing healthy ecosystems, 80% of forest cover to avoid a potential tipping point, and aquatic connectivity.
- Trade-offs amongst the different Sustainable Development Goals (SDGs) can be reduced and synergies maximized by refining the approach and developing locally-relevant indicators.
- Progress at the landscape or watershed level must be consistently scaled and supported by multilevel governance at the local, regional, and national levels.
- Efforts are required to increase effectiveness and coherence between the Paris Agreement and the 2030 Agenda.
- SDG targets for strengthening scientific and technological capacity and access to information must be complemented with biocultural or co-production approaches between western-science-based and Indigenous and local knowledge (ILK) systems.
- Safeguarding the rights of nature and of Indigenous peoples and local communities (IPLCs) is essential to achieving the 2030 Agenda in the Amazon.
- The Amazon has been significantly affected by the COVID-19 pandemic, possibly setting back achievement of the SDGs. The COVID-19 crisis is a wake-up call; humans are having a massive and potentially irreversible impact on nature, and achieving the SDGs is more urgent than ever.

Abstract

Within the framework of the Sustainable Development Goals (SDGs), the 17 goals can be clustered in five dimensions, each beginning with the letter P: "People, Planet, Prosperity, Peace, and Partnership". Chapter 26 discusses the relevance and limitations of the definitions of the Sustainable Development Goals for each of these five dimensions, considering the Amazonian context. For the People dimension, limitations discussed include the definition of poverty for the Amazon, the role of ecological and cultural capital, ethnic and gender disparities, and policy propositions for sustainable livelihoods. For the Planet dimension,

[a] Wildlife Conservation Society, C. Gabino Villanueva Nº 340 Entre 24 y 25 de Calacoto Casilla: 3 - 35181 SM, Bolivia, lpainter@wcs.org
[b] Amazon Environmental Research Institute, ane@ipam.org.br
[c] National Intercultural University of the Amazon, aoife.bennett@gmail.com
[d] University of Guyana, Turkeyen Campus, Greater Georgetown, Guyana, paulette.bynoe@uog.edu.gy
[e] Fundación Gaia Amazonas, Cl. 70a #11-30, Bogotá, Cundinamarca, Colombia, cguio@gaiaamazonas.org
[f] Universidad Andina Simón Bolívar de Quito, Toledo, Quito 170143, Ecuador, mariamurmis@gmail.com
[g] Fundación Pachamama, Vía Lumbisí Km 2, Office 5, Quito 170157, Ecuador, belenpaez@pachamama.org
[h] Future Generations University, 400 Road Less Traveled, Franklin, WV 26807, drobison@future.edu
[i] Fundación Gaia Amazonas, Cl. 70a #11-30, Bogotá, Cundinamarca, Colombia, mvhildebrand@gmail.com
[j] Universidad del Rosario, Escuela de Ingeniería, Ciencia y Tecnología EICT, Bogotá, Colombia, valeria.ochoa@urosario.edu.co
[k] Universidad San Francisco de Quito, Diego de Robles y Vía Interoceánica, Quito, Ecuador, vochoa@usfq.edu.ec
[l] Science Panel for the Amazon (SPA) Secretariat, Sustainable Development Solutions Network (SDSN), 475 Riverside Drive Ste 530, New York NY 10115, USA, isabella.leite@unsdsn.org

the chapter discusses the Agenda 2030 objectives to protect the planet from degradation, including through sustainable consumption and production, sustainable natural resource management, and taking urgent action on climate change, so that it can support the needs of present and future generations. Here, we discuss the limitations of the current mainstream vision that perceives nature as a collection of resources to be managed as opposed to the Amazon and nature as a subject. In the Prosperity dimension, the chapter discusses objectives to ensure access to energy for all, inclusive and sustainable economic growth, employment, resilient infrastructure, industrialization and innovation, reduced inequality within and among countries, and sustainable cities and human settlements. Policy propositions to achieve Peace in the Amazon are discussed in terms of advances and gaps, and Partnerships are analyzed across borders in the Amazon. To achieve the 2030 Agenda, multi-level governance is critical to leverage results obtained through the localization of goals, targets, and indicators at a landscape and watershed scale, including self-determined Life Plans; thus, placing the People, Prosperity, Peace, and Partnership dimensions within the ecological limits, or thresholds to disturbance, of the Amazon Basin, namely maintaining healthy terrestrial and aquatic ecosystems, 80% of forest cover, and aquatic connectivity. This green and inclusive vision must be promoted as part of the post-COVID-19 recovery and a Global Partnership for a Living Amazon established to channel resources in recognition of the global importance of the Amazon for a healthy planet.

Keywords: Sustainable Development Goals, 2030 Agenda, Living Amazon Vision, nature-based solutions.

26.1 Introduction

At the turn of the millennium, with the aim of reducing extreme poverty and its many manifestations, the United Nations (UN) established the Millenium Development Goals (MDGs). The MDGs comprised a set of eight measurable goals to be achieved by 2015 and galvanized unprecedented shared efforts from the international community. When the Millennium Development Goals concluded in 2015, inequalities persisted within many countries, and there was increased concern over anthropogenic impacts on the environment. In response, in 2015, Member States of the United Nations unanimously adopted the 2030 Agenda for Sustainable Development. This agenda, which includes 17 Sustainable Development Goals to be achieved by 2030, comprised five dimensions: People, Planet, Prosperity, Peace, and Partnership (United Nations 2015).

In the last 20 years, a significant amount of public resources have been channeled into the Amazon region for the implementation of the MDGs and SDGs, and some progress has been made in reducing extreme poverty, increasing access to water and sanitation, improving education, establishing protected areas, and gaining legal recognition of Indigenous lands (CODS 2020; Collen 2016; for protected areas and Indigenous territories, see Chapter 16). However, all eight Amazonian countries are still lagging in achieving all indicators, and only Colombia is on track to achieving poverty eradication indicators by 2030 (comparable data is not available for French Guiana). Overall, current trends imply that no country will achieve the SDGs in the next 50 years (CODS 2020). Additionally, despite some isolated policies aimed at supporting more sustainable pathways post-2015, all countries have largely continued to implement development models that increase social inequalities and are based on unsustainable economic activities, including agricultural expansion, mining, oil and gas, as well as timber extraction, that ultimately lead to environmental degradation, labor informality, poverty, inequality, weak health and social infrastructure, corruption, and violence against IPLCs (see Chapters 14–21). Expansion of the road network, which began in the 1960s, is a common driver of deforestation and encroachment into protected areas and Indigenous lands. Not surprisingly, this has increased the level of violence and social unrest across the region. The COVID-19 crisis has exacerbated poverty, inequality, and the

Figure 26.1 Living Amazon Vision and the SDGs.

pattern of dependence on primary production (ECLAC-CEPALSTAT 2021; INPE-PRODES 2021; Fellows *et al.* 2021; Abeles *et al.* 2020).

Countries in Latin America and the Caribbean (LAC), and those in the Amazon are not an exception, have faced challenges in identifying and reporting indicators of national progress towards the 2030 Agenda (CEPAL 2019a). An effort to address this issue was made by the SDG Center for Latin America and the Caribbean (CODS) with the support of the United Nations Sustainable Development Solutions Network (SDSN), in which new metrics were identified to compare advancement in the region (CODS 2020). We use these measurements to evaluate progress towards achieving the 2030 Agenda in the Amazon.

The SDGs can be grouped around five intertwined dimensions, "People, Planet, Prosperity, Peace, and Partnership". In this chapter, we argue that in order to maintain ecosystem integrity and promote economic prosperity and social justice for the Amazonian citizens of today and tomorrow, we must look beyond the vision of nature as a collection of natural resources to be managed for social and economic development. This chapter reinforces the Living Amazon Vision proposed in Chapter 25 as an urgent alternative to current trends in the Amazon, placing People, Planet, Prosperity, Peace, and Partnership within the ecological limits of the Amazon Basin (Figure 26.1).

This means ensuring that actions to respond to each dimension are compatible with maintaining healthy ecosystems, the 80% forest cover required to avoid a potential tipping point in the Amazon (Nobre *et al*. 2016, see also Chapter 24), and aquatic connectivity. It also requires increasing the effectiveness of and coherence between the Paris Agreement and the 2030 Agenda, including true cost–benefit evaluations of development projects and their ensuing impact on natural capital.

26.2 Evaluation of relevance and limitations of definitions of sustainable development in the Amazon

26.2.1 People

The 2030 Agenda states under the People dimension, "We are determined to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfill their potential in dignity and equality in a healthy environment". The 2030 Agenda establishes People as one of the overarching core elements, under which five of the sustainable development goals are included: No Poverty (SDG 1), Zero Hunger (SDG 2), Good Health and Well-being (SDG 3), Quality Education (SDG 4) and Gender Equality (SDG 5).

According to the CODS's 2019 SDG index, there was already a moderate to significant lag in the "performance" of Amazonian countries in achieving SDG indicators under this dimension (Figure 26.2) prior to COVID-19, in comparison with global averages. These comparisons are made using a list of indicators selected, in part, based on the availability of data (Annex 26.1). Additionally, in almost all cases, Amazonian countries were also not advancing at an appropriate rate, or "trend", to achieve these goals by 2030 (Figure 26.2). This index distinguishes between negative trends, no progress, moderate progress (a linear trend lower than 50% of what would be required to achieve the goal in 2030), and values above 50% that are classified as following the expected trajectory.

This situation has worsened as a result of the COVID-19 pandemic. Despite having a population that is much younger than that of the USA/Canada and Europe, LAC is the region with the second-highest cumulative death rate as a result of COVID-19 in the world. It is also likely that there is significant under-reporting of COVID-19 deaths (Roux *et al*. 2021). Both under-reporting and high death rates are the result of weak public health systems, limited social safety nets, and high levels of inequality. Inequality is directly evident in health outcomes; for example, cases among Indigenous people in Brazil have been under-reported by 14% and deaths by 103%. Similarly, incidence and mortality rates in the Brazilian Legal Amazon were 136% and 110% higher than the national average (Fellows *et al*. 2021). Moreover, uneven access to vaccines and healthcare creates inequalities among countries in the region (CEPAL 2021). Universal access to COVID-19 vaccines is imperative, and regional and global solidarity is required to reduce inequalities, mitigate social impacts, and accelerate recovery.

The COVID-19 pandemic is likely to exacerbate inequality by setting back advances in reducing poverty and extreme poverty in LAC by 12 and 20 years, respectively (ECLAC 2021a, b). This indirect and lasting impact will have a more significant effect on rural areas, owing to higher rates of poverty (45.7% in rural areas, relative to an overall average of 30.5% in 2019) and extreme poverty (21.2% in rural areas, relative to 11.3% overall in 2019). It will also affect children between 0–14 years old living in poverty (47.2%) and extreme poverty (19.6%), and Indigenous people living in poverty (46.7%) and extreme poverty (17.3) in 2019 (ECLAC 2021a).

Education will suffer long-term impacts. Thus far the pandemic has affected over 170 million students across different levels in LAC (World Bank 2021a). Remote learning strategies have excluded 46% of children aged 5–12 years living in households without internet access (ECLAC 2021b). This is likely to result in poor academic performance in primary and secondary school, increased dropout rates, and decreased physical and emotional well-being, including loss of access to school meals (World Bank 2021a). The pandemic has also

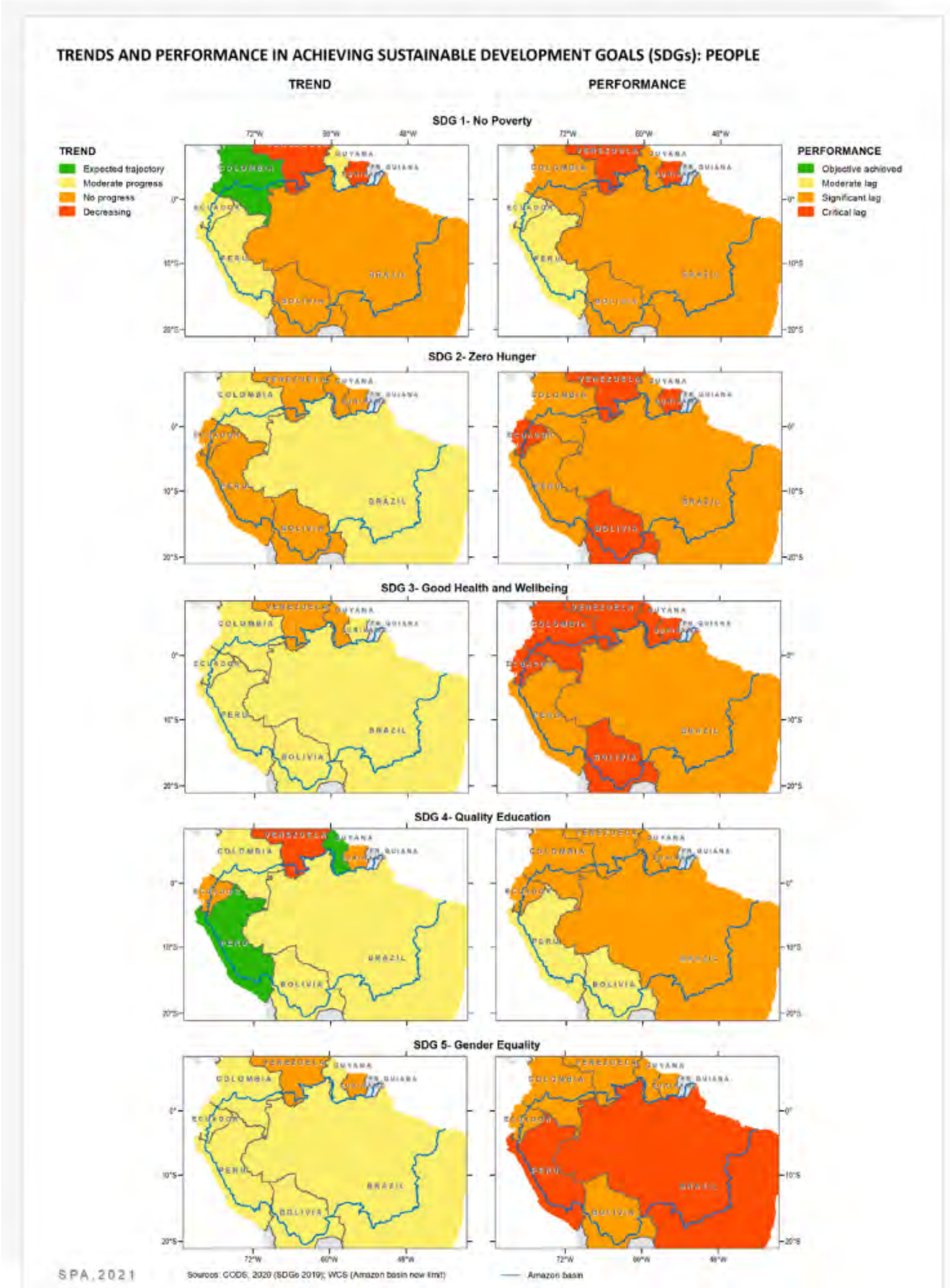


Figure 26.2 Performance and trends in achieving SDGs of the People dimension (based on 2019 Data CODS 2020).

affected food security, as lockdowns reduce both physical access to food and household income (Devereux *et al.* 2020).

Regarding gender equality, women have been on the front lines in the response to the pandemic. In 2019, women represented over 70% of health sector staff in Amazonian countries. Additionally, women have faced long work days and high risk of infection, as well as greater domestic responsibilities and increased domestic violence. Adolescent fertility rates are expected to increase and affect the most vulnerable girls due to reduced access to birth control, abuse and sexual violence, and suspension of sexual education programs, leading to increased unwanted pregnancies (ECLAC 2021b). Government responses to increased violence against girls and women since the pandemic began have been varied; Colombia is a good example, designating services to protect women as essential (ECLAC 2021b).

26.2.1.1 What are the limitations of the definition of poverty in the Amazon?

Accepted and widely used definitions of poverty have shortcomings; most operational definitions do not provide an objective concept of the 'problem' (Piachaud 1987). Despite limitations, definitions remain central to decision making about the design and implementation of appropriate sustainable development objectives (Schreckenberg *et al.* 2018). Poverty is generally measured by comparing a person's or family's income, derived through a specific (or multiple) livelihood strategy(ies), to a set threshold or minimum amount of income needed to cover basic needs.

The Human Development Index (HDI) arose as an effort to include human welfare in development assessments, which before 1990 had previously considered only Gross National Product (GNP) (UNDP 1990). It is a composite index of life expectancy, education, and *per capita* income indicators, which are widely used today to rank countries into tiers of human development (including poverty). The HDI includes more than the accumulation of commodities and financial wealth to include other determinants of long, healthy, and creative lives. However, although the HDI is a critical index to guide poverty alleviation, it is based on national averages and can mask inequality.

In 2020, the Human Development Report addressed the challenges faced in the Anthropocene, the period during which human activity has a dominant influence on Earth's climate and the environment. It adjusted the HDI to take into account the pressures placed by humans on the planet, creating the Planetary Pressures-adjusted Human Development Index (PHDI) (UNDP 2020).

The poverty eradication targets included under SDG 1 in Agenda 2030 include support for people harmed by climate-related extreme events and other economic, social, and environmental shocks and disasters, in addition to ending poverty and ensuring social protection for all. SDG 2 seeks sustainable solutions to end hunger and to achieve food security, and its targets focus on improving access to food and the widespread promotion of sustainable agriculture. The targets for SDG 3 include improving reproductive, maternal, and child health; addressing priority communicable and non-communicable diseases; and achieving universal health coverage and access to medicines and vaccines. SDG 4 targets focus on securing access to quality education and lifelong learning opportunities.

Although there is certainly progress in the integrality of development metrics, the need for generalizations at the global level impedes diversity and cultural specificity. Because of the lack of similar data between different countries in the Amazon and Latin America as a whole, comparisons almost exclusively rely on income, consumption, and access to social assistance programs and basic services, referring to government-led health, education, and infrastructure programs (CODS 2020). The lack of mainstreaming of local solutions in development metrics hinders progress to adequately consider all forms of poverty alleviation strategies and hence to channel development funding to these diverse approaches. The challenge of how to address multidimensionality and complexity in the definition of poverty, and indeed sustainable livelihoods, especially on the ground and in specific contexts, is not new, and the need for subnational approaches for effective implementation is broadly recognized. "Localizing" is the process of taking into account subnational contexts in the achievement of the 2030 Agenda through the identification of goals, targets, and indicators for determining the means of implementation (UN-Habitat and UNDP 2016). The Global Taskforce of Local and Regional Governments brings together the major international networks of local governments to present their perspectives on the SDGs, the global climate agenda (Nationally Determined Contributions [NDCs] to the Paris Agreement), and the New Urban Agenda.

However, a similar platform for the support of Indigenous territories is lacking, and IPLCs' (and their institutions') own definitions of poverty remain poorly understood and operationally mostly absent in sustainable development planning, design, and implementation in the Amazon. Colombia represents a notable exception, having recognized Indigenous autonomy and supporting access to government funds to support their consolidation. This is true despite the numerous advances made by Indigenous movements in establishing Indigenous territorial plans in all countries in the region. Indigenous territorial plans, also called Life Plans, share a common characteristic of representing the shared consensus for the management of a collective Indigenous land, including organizational aspects, territorial zoning, natural resource use, cultural revalorization, women's rights and their needs for basic services, and engagement with the state and non-state stakeholders (Lehm 2019). One way of thinking about poverty in a rich, heterogeneous, and multidimensional way is to think about the different types of capital available in a specific place.

26.2.1.2 Natural and Cultural Capital: Rethinking sustainable 'livelihoods'

The socio-economic circumstances of people in the Amazon are not influenced merely by their individual actions and behavior, but more importantly, by various assets that are available to them and their level of engagement in decision-making processes regarding their self-determined development (Gutiérrez-Montes *et al.* 2009). People defined as 'poor' by widely-accepted definitions may not possess cash or savings; however, they may possess both the material and non-material assets to meet their basic needs (Davies and Smith 1998; Verrest 2007). The Sustainable Livelihood Framework identifies five types of assets or capital: natural assets, human assets, physical assets, social capital, and financial assets (DFID 2000). Recognition of these capitals and plans for a successful investment strategy in all five asset classes would lead to a sustainable society where stocks are enhanced and not depleted.

Critically, in the Amazon, natural and social capital are unique and highly threatened. Time and natural processes, coupled with environmental heterogeneity, climate, and biotic interactions, have produced an exceptional diversity of Amazonian species, genes, and ecosystem functions (see Chapters 3 and 4). In the Amazon, biological and cultural diversity are intrinsically connected and have co-evolved as social-ecological systems, designated as biocultural diversity. Amazonian IPLCs have played an important role in shaping, protecting, and restoring Amazonian ecosystems and biodiversity under different changing contexts (see Chapters 8, 10, and 13). Hence, natural and social capital are irreplaceable, and over-extraction is already resulting in diminishing returns and critically threatening the rights of future generations (Dasgupta 2021).

Kinship and social networks, local and hybrid (including increasingly intercultural) knowledge systems, beliefs, customs, norms, language, and a wide range of culturally-related activities, such as oral folklore, arts, crafts, music, and gender roles, can play a significant role in the sustainability of human societies and their respective sustainable livelihoods. Social organization around cultural capital in supporting (or not) other capitals (economic, human, physical, ecological) is essential to maintain or initiate sustainable livelihoods. For example, several studies show that even relatively modern supply chains of natural resources, such as charcoal, are based and rely on kin networks (Bennett-Curry *et al*. 2013).

Cultural capital, through local to international coalitions and through its power to reconcile and incorporate new realities into existing knowledge and belief systems, is critical to strengthen resilience and guide adaptation to the climate, biodiversity, and COVID-19 crises. While still limited, increasing attention is being directed towards the role of culture as a social capital that contributes (or limits) the development and well-being of people, as well as to the capacity for territorial management for a diversity of objectives, including conservation. This is best illustrated in the Amazon by initiatives linked to spiritual values, such as the Amazon Sacred Headwaters Initiative in Ecuador and Peru (Koenig 2019), and with efforts to implement Indigenous territorial management plans or Life Plans in their multiple dimensions (Lehm 2019). The Amazon Sacred Headwaters Initiative, for example, builds a shared vision among Indigenous peoples, NGOs, philanthropic foundations, social entrepreneurs, and governments towards establishing a bi-national protected region that is off-limits to industrial-scale resource extraction and governed in accordance with Indigenous principles of cooperation and harmony.

Given the scale of the threats and connectivity requirements to maintain the natural capital of the Amazon, it is important to remember that cultural capital is not limited to the local level. There are multi-level vertical organizational structures as well as horizontal linkages between Indigenous territorial organizations at the national, regional, and global levels, enabling new dynamics of political representation and empowerment within the international policy arena. Therefore, development in the Amazon can be considered a cultural as much as an economic or social process. Thus, it is necessary to increase or enhance awareness of locally-specific cultural traditions, strengths, and perspectives through intercultural research and communication (for more on intercultural education, see Chapter 32).

26.2.1.3 Ethnic and gender disparities in the Amazon

The 2030 Agenda has three guiding principles: i) human-rights-based approach; ii) leaving no one behind; and iii) gender equality and women's empowerment. SDG 5 aims to ensure equal opportunities for women and girls by removing discrimination and violence, and by improving access to paid employment, sexual and reproductive healthcare, and decision-making power.

Brazil and Peru have a critical lag in achieving gender equality, and all other countries are significantly behind average global performance (Figure 26.2). Moderate progress has been achieved across the region on reducing gender gaps in access to education, except in Suriname and Venezuela. However, reported gender-based violence is high; for example, in Colombia, 39% of Amazonian women indicated they have recently been victims of physical violence, and the region has the highest incidence of female rape in the country, 7 women per 100 (Collen 2016). In 2014, the United Nations International Children's Emergency Fund (UNICEF) reported a third of women in Guyana had been the victim of gender-based violence (GBV) (Contreras-Urbina *et al*. 2019). As mentioned above, there has been an increase in violence towards women and children during the COVID-19 pandemic.

Although there has been some progress in reducing inequalities in the Amazon, Indigenous peoples, especially Indigenous women, still face higher rates of illiteracy, poverty, infant mortality, and maternal fertility, as well as lower education rates (Collen 2016). These global measurements do not take into account access to subsistence fisheries, hunting, and agriculture, despite the fact that-inclusion of these non-market resources can halve estimates of poverty in Indigenous communities with access to healthy rivers and forests (Salinas *et al*. 2017). Consolidating and maintaining access to ancestral lands and a healthy environment is a key strategy to implement the 2030 Agenda in the Amazon. Documenting and communicating this contribution is also crucial to increase government support to Indigenous territorial management as part of national poverty alleviation strategies. To ensure their inclusion in poverty alleviation strategies and capture the inequalities they face across all SDGs, Indigenous peoples have been advocating for data disaggregation and the inclusion of community-based data in official statistics.

Ethnic and gender disparities in the Amazon arise from deep-rooted, systemic, historical dynamics and have important cultural, psychological, and identity dimensions, as well as a history of distrust, impeding progress. There is structural violence and injustice at every level of governance, whereby social structures or institutions prevent vulnerable people from meeting their basic needs by failing to safeguard their rights. These power dynamics result in a lack of recognition of land rights of Indigenous people and local communities, limited participation of women from IPLCs in decision-making processes, and poor access to healthcare, education, and employment for rural communities (World Bank 2015).

26.2.2 Planet

The 2030 Agenda states "We are determined to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations." In this section, we evaluate the most relevant aspects of this vision and the key gaps that exist for the Amazon Basin. Four of the sustainable development goals are included under "Planet": Clean Water and Sanitation (SDG 6), Responsible Production and Consumption (SDG 12); Climate Action (SDG 13), and Life on Land (SDG 15). Conservation and sustainable use of the oceans, seas, and marine resources (SDG 14) is not included in this discussion because it is of limited relevance for the Amazon Basin.

26.2.2.1 SDG 6: Clean Water

Targets for SDG 6, Clean Water, include universal and equitable access to drinking water and sanitation; improved water quality and quantity by addressing sources of pollution and increasing efficiency of use; integrated water resource management, protection and restoration of critical ecosystems; international cooperation and capacity building, as well as local community involvement. These targets reflect the importance of natural ecosystems for water provision and access to water quality and quantity as a basic human right and key requirement for sustainable development. They also reflect the need to address pollution, current pressures, and conflicting demands for fresh water in the context of climate change.

Access to clean water is crucial for reducing poverty and inequality and enabling peace, justice, and sustainability. Mainstreaming water in national and subnational planning for energy, agriculture, infrastructure, and the environment is critical for increasing policy coherence and effectiveness, optimizing the use of limited resources available to implement the 2030 Agenda, and integrating strategies to end poverty in order to avoid conflicting impacts. As such, in the Amazon and all Latin America, there have been advances in relevant legislation, including the recognition of access to water as a human right. However, access to safe water remains a challenge.

Throughout the region, illegal mining, lack of access to sewage systems, agroindustry, and other activities have a negative impact on water quality and people's health (Rocha-Román *et al.* 2018). By 2015, mining had polluted at least 30 rivers in the Amazon and affected 88 Indigenous lands, including 32 in Peru and 29 in Colombia (Vallejos *et al.* 2020; for information on the impacts of mining on aquatic systems, see Chapter 20). Pollution of surface waters threatens human health and aquatic life in areas where the expansion of agroindustry is occurring. For example, in Brazil, after relaxing processes to approve the use of pesticides in 2019, the government allowed the use of at least 474 new

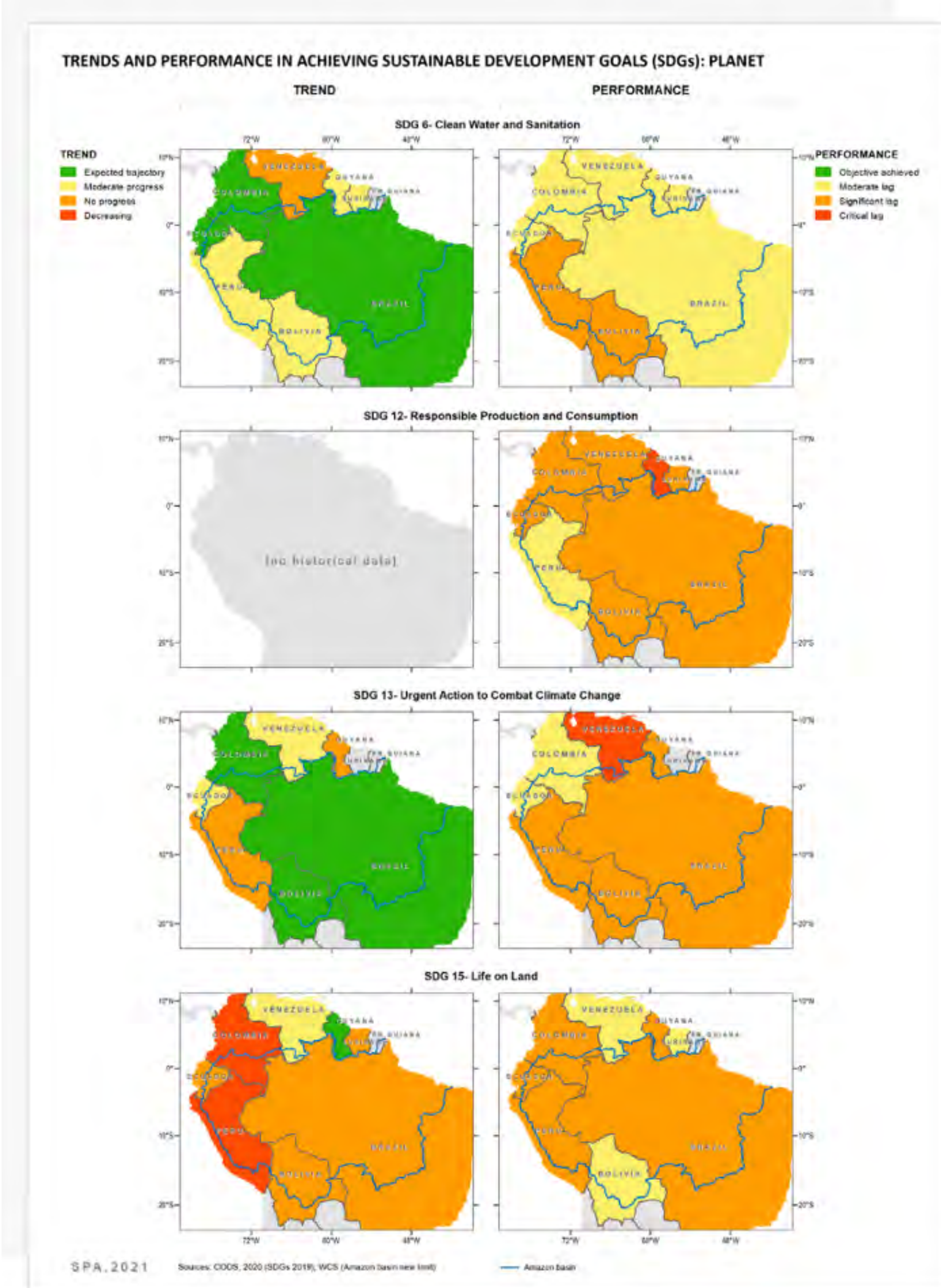


Figure 26.3 Performance and trends in achieving SDGs of the Planet dimension (based on 2019 Data CODS 2020).

agrochemicals, and in 2020 this number increased to 493, including many banned in other countries (Ferrante and Fearnside 2019; Brazil 2021).

Even though the Amazon is the largest watershed in the world, the Regional Technical Team on Water and Sanitation of the World Health Organization (WHO) stated in 2018 that the majority of the 8.5 million people in Latin America without access to potable water are found in Brazil, Colombia, Peru, Ecuador, and Bolivia. According to Fundación Aquae (2017), in 2017, 89% of the people living in the Peruvian Amazon had no access to drinking water, and 38% of households in the state of Amazonas had no household connections to running water in 2018 (WHO and UNICEF 2019). The majority of municipalities in the Amazon Delta and Estuary have less than 20% of households with sewage coverage (Mansur *et al*. 2016; see also Chapter 14). Lack of access to basic sanitation services is an obstacle to regular hand washing, a critical action to reduce disease transmission. In addition, because only a limited number of households in the Amazon are served by sewage collection or treatment, there is significant release of contaminants (pharmaceuticals and other wastewater contaminants) into freshwater ecosystems, especially downstream from urban areas such as Manaus (Fabregat-Safont *et al*. 2021).

Overall, the Amazon, as well as the rest of Latin America, has made moderate progress in providing access to water and sanitation to most of the population. This progress is markedly slower in rural areas (CEPAL 2019b), and the region still shows a moderate lag in its performance in comparison toaverage global performance in achieving selected indicators. At the national level, Brazil, Colombia, and Ecuador are following a trend that will allow them to ensure adequate access to water and sanitation for all their population by 2030. However, this trend is not reflected in the Amazon region. For example, in the Brazilian Amazon, in 2018, only 54% of the population had access to safe water and only 15% had sewage (Santos *et al*. 2018). Even at the national level, Guyana, Peru, Bolivia, and Suriname will not fully reach this goal, in particular Peru and Bolivia, which have a significant gap in coverage. Meanwhile, Venezuela's progress has halted (Figure 26.3 and Annex 26.1 for details of indicators used). Access to water is not always stable and of high quality because of droughts and poor infrastructure. Amazonian countries face a greater frequency, intensity, and geographic extent of floods and droughts (see Chapter 22).

Many of the principal cities in the region increasingly experience water scarcity as a result of poor planning, climate change, and deforestation (World Water Week 2020). These threats are broadly included in the clean water targets measured through three dimensions: i) developing an enabling environment, ii) appropriate institutional capacity, and iii) financing and management instruments.

The institutional framework for watershed management in each country is very heterogeneous. Brazil, Colombia, Ecuador, Venezuela, and Peru established basin management bodies by law. Bolivia implements watershed management programs, while Guyana has a draft policy and roadmap for Integrated Water Resource Management. Suriname has yet to develop an institutional basis for integrated management of watersheds beyond specific sectorial interests. Even where an institutional framework exists, it rarely has the necessary technical capacity, continuity, enforcement, international coordination, and financial resources to fully achieve integrated watershed management objectives (Dourojeanni Ricordi 2020).

Although the need to work across different scales, including the transboundary scale, is addressed in the 2030 Agenda (UN Water 2020), the role of the Amazon for water provision at a global scale is not addressed. Its immense size and political divisions prevent both conservation and sustainable development projects from being planned at the Basin scale. This has made it particularly difficult to address threats such as mining, sewage, deforestation, and dams, but there are some encouraging advances. There is increasing progress and collaboration between Colombia, Peru, Brazil, and

Ecuador in the Putumayo Basin; and between Bolivia, Brazil, and Peru in the Madre de Dios watershed. All eight Amazonian countries have also come together through an agreement between the Amazon Cooperation Treaty Organization (OTCA), the United Nations Environment Program (UNEP), the Global Environment Facility (GEF), and the Organization of American States (OAS) to implement a project for the Integral and Sustainable Management of Cross-border water resources in the Amazon River Basin (OTCA/PNUMA/OEA 2006).

Connectivity between Indigenous territories and protected areas at a landscape and watershed level is an important enabling condition; thus, Indigenous people are key stakeholders in achieving integrated watershed management, not passive recipients of equitable access to basic services. In addition, transboundary cooperation agreement indicators should address the level to which Indigenous communities from different countries are cooperating on territorial management. Indicators could include recognition of the rights of Indigenous peoples, and the integration of Indigenous Life Plans within watersheds by relevant sectoral policies, as well as the degree of inclusion of Indigenous peoples as rights holders in the implementation of these policies.

The cultural importance of water and the sacred nature of rivers is critical for integrated river basin management with the participation of Indigenous people. Many Indigenous people have a deep connection with water bodies, identifying them with ancestors, forest spirits, and their history, as is the case of the Kukama (WCS 2016) and the sacred headwaters initiative in Peru and Ecuador (Koenig 2019). The cultural value of water does not seem to be included in SDG 6; culture could come into play through references to public participation (Target 6a and 6b), but with no explicit mention it is easily overlooked. There are additional opportunities to specifically include Indigenous participation in monitoring target 6.5, which evaluates the degree of integrated water resources management implementation by including culture in environmental flow requirements (target 6.4.2). The role of women in the affirmation and transmission of these cultural values is particularly important in the Amazon. Thus, the connections between SDGs 5 and 6 are critical; specifically, ensuring that women are empowered to participate in SDG 6 activities and allowed to include the cultural values of water in the concepts encompassed by Goal 6. Recent advances in promoting intercultural dialogue between ILK and scientific knowledge represent an opportunity to integrate cultural management practices into national or regional watershed management plans.

26.2.2.2 SDG 12: Responsible Production and Consumption

With regard to sustainable production and consumption, SDG 12 targets and indicators reflect the impact of socioeconomic and demographic change resulting from the growing middle class in Amazonian countries, and the need to respect planetary boundaries. Action to address climate change is prioritized because of its multiple impacts on nature and people, particularly marginalized groups. These targets recognize that there are limits to the extent and intensity of natural resource extraction (see Annex 26.1 for details of specific indicators).

In Colombia, Bolivia, and Ecuador, retail food losses equate to the amount of food required to reduce the percentage of undernourished people in their populations by half, whereas Brazil and Guyana could reach zero hunger with the amount of food wasted from retail alone. Therefore, addressing food losses and waste is key to eradicating hunger in the Amazon (FAO 2015).

Colombia, Ecuador, and Peru established strategies to promote a circular economy since 2019, and all Amazonian countries have laws or strategies for waste management. Single-use plastic consumption has increased during the COVID-19 pandemic, with an exponential increase in the use of *inter alia* gloves, masks, food packaging, and wrapping. Although global production of single-use plastic has increased worldwide, recycling programs were suspended, negatively affecting 1.8 million waste pickers in LAC who are responsible for recovering approximately 50% of recycling material (OEP and BID 2021).

Making use of digital innovation is essential to realize circular economy opportunities. Colombia, Brazil, and Bolivia are rapidly adopting digitally-driven innovation (Muruzábal 2018). Nevertheless, in the absence of policy, fiscal, and training support, these opportunities are likely to be taken up by larger companies, leaving small businesses at a disadvantage. The same risk of monopolization is present in the agricultural sector. In Bolivia, Ecuador, and Peru, the agricultural sector employs approximately 30 percent of the population, of which a large proportion are smallholders. Therefore, a transition to a circular, nature-based economy must prioritize smallholders and Indigenous land rights, as well as food sovereignty in order to avoid land grabbing by large-scale agro-businesses (Mills 2015; see also Chapters 14 and 15). This transition also requires support from the international community in order to create and maintain sustainable food systems (e.g., the European Union-Mercosur agreement includes commitments to tackle deforestation as well as social safeguards). Close international cooperation and the setting of robust standards is necessary to ensure that the transition to a circular bioeconomy delivers real environmental benefits and promotes innovation in high value-added sectors through research.

The SDG for responsible production and consumption aims to decouple environmental degradation from economic growth and promote resource use efficiency by applying life cycle thinking. In the case of the Amazon, this may involve leveraging traditional knowledge regarding production and natural resource management practices, rather than new practices altogether. Chapter 25 presents a critique of the idea of infinite economic growth.

To achieve transformative change and reverse the current advancement of degradation in the Amazon, two elements are missing in these targets and their indicators. First, indicators related to the sustainable management and efficient use of natural resources do not consider resource flows driven by demands that originate in markets located outside the region. In this case, consuming countries do not account for the environmental impact and human cost of their demand for beef, soy, oil and gas, timber, and gold. Second, this vision is limited by the general understanding of nature as a collection of natural resources to be managed and excludes the existence of different spiritual and immaterial connections with nature, as well as its value for all life on Earth (see Chapter 10).

These different value systems, sometimes referred to as "*Buen Vivir*", represent an important potential to couple responsible production and consumption with respect for human rights and opportunities to collaborate with Indigenous people. These opportunities include strengthened governance over Indigenous territories covering more than a quarter of the Amazon (see Chapter 16) and the livelihood and climate benefits this entails. Additionally, strengthening biocultural or co-production approaches between Western and Indigenous knowledge systems would complement the targets focusing on scientific and technological capacity, as well as increase access to relevant information and awareness. Co-production and biocultural approaches do not imply a return to the past, but Targets 12.2 (sustainable management and efficient use of natural resources), 12.5 (reduce waste generation), and 12.8 (information and awareness) could all include traditional production practices. One example is the reintroduction of leaves as food wrapping rather than plastic, whether biodegradable or recyclable. Target 12.7 (public procurement practices) should mention the purchase of local and traditional products as a priority. Consistent with this, information and awareness programs (Target 12.8) should aim to include traditional practices and knowledge that are conducive to the attainment of SDG 12.

26.2.2.3 SDG 13: Urgent Action to Combat Climate Change

SDG 13 targets relate to urgent action to combat climate change and its impacts, address resilience

Table 26.1 Advancement of Amazonian countries in fulfilling commitments to the Paris Agreement. Developed with data from Climate Watch (2020)

	Bolivia	Brazil	Colombia	Ecuador	Guyana	Peru	Suriname	Venezuela
Submitted INDC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NDC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Updated NDC	No	Yes	Yes	No	No	Yes	Yes	No
Inclusion of mitigation targets	No	Yes	Yes	Yes	No	Yes	No	Yes
Inclusion of adaptation targets	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Specific Legal/policy frameworks to enhance NDC	No	Yes	Yes	Yes	No	No	Yes	No
Potential alignment between NDCs and SDGs	1	0	7	0	2	0	3	3

and adaptive capacity to hazards and natural disasters, integrate climate change measures into national policies, improve education and capacity building, facilitate global financial mobilization, and support inclusive and climate-resilient planning and management. The urgency of addressing climate change in the Amazon is two-fold: i) the Amazon is a giant carbon reservoir holding 150–200 billion tons of carbon in its soil and vegetation (see Chapter 6) and its forests are a giant cooling mechanism (see Chapter 7), thus any solution to tackle global climate change must consider reducing deforestation in the Amazon; and ii) climate change and deforestation threaten to reduce the role of the Amazon as a water processor of global importance by reducing atmospheric moisture transport and respective recycling of precipitation (Chapter 22). In fact, studies show that the Amazon is close to reaching a potential tipping point of no return, beyond which tropical forests could be replaced by savannah-like degraded ecosystems across over 60% of the Basin (Nobre *et al.* 2016). Chapter 24 examines the different potential tipping points and suggests that it is likely that novel feedbacks associated with invasive plants and human-modified landscapes will lead to open degraded and secondary forest over broad areas. SDG 13 is relevant to the Amazon at four scales: local, national, regional, and global. Targets and indicators included in this goal, as currently stated, relate to the national level, except for commitments to global finance mobilization. All countries in the Amazon are signatories of the Paris Agreement and are implementing policies to combat climate change under the United Nations Framework Convention on Climate Change (UNFCCC). Advancements towards such commitments are presented in Table 26.1. All countries have submitted their Intended Nationally Determined Contributions (INDCs) and Nationally Determined Contributions, and Brazil, Colombia, Peru, and Surinam updated their NDCs in 2020. Mitigation targets are included in many of these updated commitments, but not by Bolivia, Guyana, and Suriname. All communications, except those of Brazil, include commitments to increase adaptation capacity. Half of the countries have included specific policy frameworks to enhance NDCs; potential alignment with the 2030 Agenda is mentioned by Colombia and to a lesser degree Venezuela, Suriname, Guyana, and Bolivia.

The Paris Agreement is a powerful tool for action because it involves specific targets to which governments can be held accountable. Additionally, there are linkages between SDG indicators and the expected results of NDC implementation. Nature-based solutions underpin the SDGs by supporting vital ecosystem services, biodiversity, access to fresh water, improved livelihoods, healthy diets, disaster risk reduction, and food security from sustainable food systems. It is important to highlight that the COVID-19 pandemic only had a temporary effect in reducing CO_2 emissions, and total emissions are still increasing consistent with a temperature rise of 3°C this century (UNEP 2020).

Reducing deforestation and restoring forest cover are recognized by all Amazonian countries within their NDC documents (UNFCCC 2021). This is particularly relevant as we have just entered the UN Decade of Restoration. However, we need urgent conservation and restoration actions to address rapid land-use change and deforestation arising from direct, indirect, and cumulative threats across the Basin, such as increased road infrastructure, oil and gas, gold mining, and expansion of the agro-industry (see Chapters 27–29), operating under a common regional vision (see Chapter 25), and addressing international forces that may be driving these phenomena. Additionally, a common regional vision is required if we are to avoid the effects of deforestation on the South American monsoon system (Boers *et al.* 2017). Initiatives such as the NDC partnership (2018) and NDC Latin America and the Caribbean (Samaniego *et al.* 2019), a digital information platform to support action on Climate Change in Latin America and the Caribbean, represent models that can guide the establishment of a regional vision to address climate change. At a subnational scale, progress achieved in engaging local governments in the 2030 development agenda is encouraging (e.g., through communities of practice such as the Local 2030 network). Similarly, local climate change action is critical to strengthen the existing targets and indicators of SDG 13 (e.g., the Governors for Climate Alliance in Brazil) and recognize different identities and knowledge systems within countries. Local programs to enhance education, raise awareness, and improve human and institutional capacity are critical to climate change mitigation, adaptation, impact reduction, and early warning. Furthermore, encouraging governments to consider local knowledge and practices in the climate change measures of Target 13.2 would significantly contribute to attaining SDG 13 through environmental governance, leading to reduced deforestation on Indigenous lands and in subnational protected areas and the sustainable use of nature.

26.2.2.4 SDG 15: Life on Land

Targets for SDG 15 address actions to protect, restore, and promote the sustainable use of terrestrial ecosystems; emphasize equitable access and benefit-sharing; promote sustainable forest management; combat desertification; halt and reverse land degradation; and prevent biodiversity loss including through halting the illegal wildlife trade, integrating ecosystems and biodiversity into development policies, and mobilizing financial resources.

These targets highlight major direct threats to terrestrial ecosystems, which must be addressed through actions both within and outside of protected areas, for example within Indigenous lands, allowing for conservation of forests at the Basin scale. To achieve SDG 15, four approaches are critical: i) acknowledgement of the mutually dependent relationship between forests and rivers, and bordering or related ecosystems, such as wetlands, leading to the need to include conservation and management actions at a watershed scale; ii) inclusion of biodiversity and species-focused management, and not only ecosystem conservation, as management objectives within and outside of protected areas; iii) recognition of the spiritual and cultural values of nature, and thus their inclusion as objects of the protection and restoration measures for the sustainable use and management of land; and iv) inclusion of IPLCs' traditional knowledge and livelihood systems into national and local planning and development processes, strategies, and accounts.

In terms of interventions, Amazonian conservation can be achieved at scale by building on the current designation of approximately 50% of the region as national and subnational protected areas, as well as Indigenous lands (RAISG 2019; see also Chapter 16). To maintain 80% forest cover, required to avoid a potential tipping point (Lovejoy and Nobre 2019), these areas need to be connected through new protected areas, other effective area-based conservation measures (OECM), sustainable natural resource management plans, and restoration interventions. The Leticia Pact, signed by all countries in the Amazon except Venezuela in 2019, represents an opportunity for coordination across the Basin to maintain healthy forests and rivers by addressing natural disasters and ecosystem degradation caused by illegal mining and fires, establishing early warning systems for deforestation and degradation, monitoring climate change and biodiversity at a watershed scale, promoting responsible consumption and a new bioeconomy, empowering women and IPLCs, promoting citizen education, and mobilizing international finance in support of these objectives.

26.2.3 Prosperity

In the 2030 Agenda, the Prosperity dimension is summarized as "We are determined to ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature." The Prosperity dimension includes SDG 7 (Ensure access to affordable, reliable, sustainable, and modern energy for all), SDG 8 (Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all), SDG 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation), SDG 10 (Reduce inequality within and among countries), and SDG 11 (Make cities and human settlements inclusive, safe, resilient, and sustainable).

Since the 1990s, there has been notable progress in improving access to electricity in both urban and rural areas of Latin America (Iorio and Sanin 2019), and current trends show that most countries are moving towards achieving universal access. Despite developments in research and innovation, the practical application of sustainable energy projects remains difficult and costly. As a result, there is still a moderate to significant lag in comparison with global averages in access to affordable and clean energy in all countries in the region, and a critical lag in Bolivia (see Figure 26.4 and Annex 26.1 for details of specific indicators). It is also important to highlight that this indicator does not include trade-offs between hydroelectric project generation in lowland Amazon and emissions from forest loss, nor does it consider the impacts on ecosystems and aquatic connectivity and local fisheries, with the Madeira Basin being the most impacted by current and future planned dams based on the potential hydrophysical impacts on the fluvial systems and the distribution of biological diversity (Santos *et al.* 2020).

With regard to SDG 8, countries in the Amazon Basin show significant to critical lags in performance, and varying trends towards the achievement of decent work and economic growth. As described in Chapters 14 and 15, increased conflict over land and stagnant incomes have led to increased employment in precarious, wage-based, often seasonal, and sometimes clandestine activities to supplement family income.

The contributions of Amazonian regions to national gross domestic product (GDP) are modest, yet growing; however, this trend is the result of unsustainable economic activities linked to habitat loss and degradation. This represents a negative spiral, as it threatens the very ecosystem services that support economic growth and jobs in key sectors, such as agriculture, tourism, forestry, fisheries, pharmaceuticals, and textiles. Knowledge-based sustainable use of biological resources, or a new bioeconomy, is the only way to break this cycle and maintain climate stability and a healthy environment (see Chapter 30), both of which are critical to human well-being and reducing productivity losses due to natural hazards (ECLAC and ILO 2018). Therefore, when we discuss prosperity, we should primarily be interested in the benefits of regenerative or sustainable practices (Fath *et al.* 2019). For example, throughout the countries that share the Amazon, per capita income significantly increased between 2000 and 2004. The region as a whole tripled its per capita income in that period

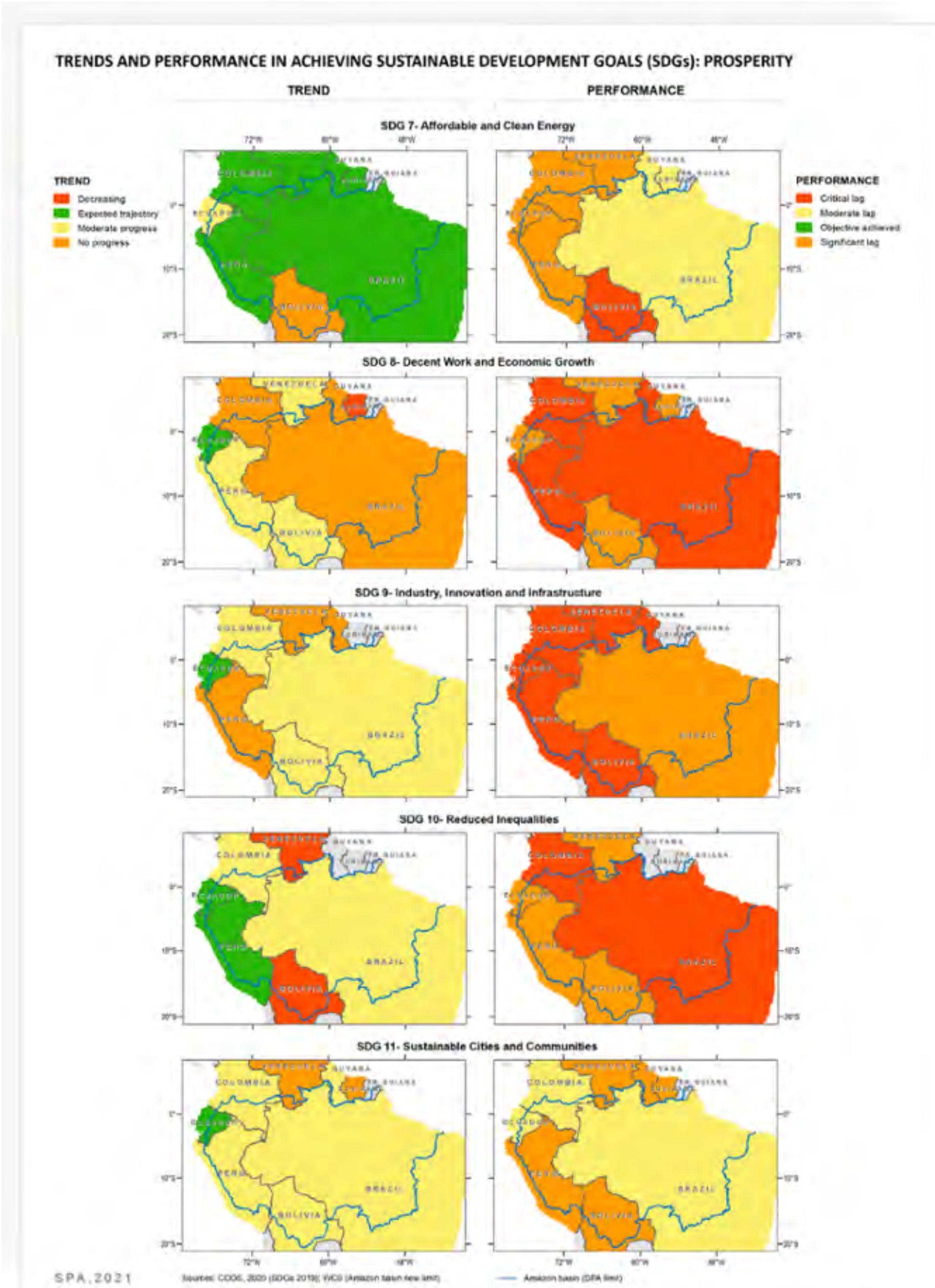


Figure 26.4 Performance and trends in achieving SDGs of the Prosperity dimension (based on 2019 Data CODS 2020).

(World Bank 2020). This was a result of increased prices worldwide for basic natural resources, both renewable and non-renewable, and the acceleration of unsustainable extractive activities across the region. These indicators need to be tied to specific regenerative development pathways. Inclusive and sustainable industrialization and innovation strongly feature in SDG 9; they are essential to move countries, and the Amazonian regions within them, away from exporting raw materials towards high-quality jobs and increased value exports that can support vibrant economies in urban and rural areas. An obstacle is access to technology, information and communication technologies (ICT), and relevant training and capacity building (UNIDO 2015).

26.2.3.1 Inequalities in the generation of wealth from Amazonian resources

There are significant inequalities in the Amazon according to 2018 Gini coefficients[1], ranging from 0.42 in Bolivia to 0.54 in Brazil (World Bank 2021b). Poor performance on SDG 8 is reflected in the high prevalence of informal employment across the Amazon, in rural areas as well as urban areas. In 2019, the informal sector represented 64% of employment in Bolivia, approximately 60% in Ecuador and Peru, and 41% in Brazil (ECLAC-CEPALSTAT 2021). The COVID-19 pandemic has negatively impacted labor markets and incomes, and, as expected, inequality and vulnerability have increased. This is not surprising as only 21.3% of the population in Latin America can work remotely. In the second quarter of 2020, formal employment rates contracted by 10.7% in Brazil, 12% in Bolivia, 16.1% in Ecuador, 21.8% in Colombia, and 34.9% in Peru, principally affecting women (ECLAC 2021a). Unemployment has also impacted informal workers; for example, in the case of Brazil, the informal employment rate dropped in the second quarter of 2020 to 36.9% (4.3% lower than in the same period in 2019), principally affecting young people aged 14–17 years (35.2%) and 18–24 years (21.9%) (ECLAC 2021a). To offset the effect of the COVID-19 pandemic, social protection measures were adopted. South American governments provided US $75,237 million in cash and in-kind transfers between March and December 2020. However, these measures were insufficient to stop poverty, inequality, and vulnerability. The rate of improvement as measured by the Gini index was already slowing before the pandemic and has since worsened, by 2.9% in 2020 (ECLAC 2021a).

Structural changes are required to address inequality. Across Latin America, women are closing the gender gap in participation in the labor force, but policies are needed to better support their participation, for example by strengthening their legal rights, improving childcare, and through educational and job training policies (Novta and Wong 2017). There are also numerous obstacles for regenerative wealth generation by IPLCs, which prevent them from accessing opportunities based on their deep knowledge of biodiversity. These obstacles further entrench the cycle of degradation and poverty linked to unsustainable extractive activities, and include inequal access to legal land rights, financial services, niche markets, and ICT. Additionally, as recognized by the Leticia Pact, global inequality in access to technology and industrialization needs to be addressed to shift the region from a source of primary natural resources (see Chapter 11) towards knowledge and service-based industries, or a new bioeconomy (see Chapter 30).

Finally, inequality is also an issue that must be considered in relation to SDG 11 (Sustainable cities and communities), particularly in a region where rapid urbanization has led to a lag in the provision of adequate and sufficient waste management, healthcare, education, and protection from environmental risks such as floods and landslides. Cities and local goverments recognize the need to improve (Figure 26.4, UCLG 2018). The discourse includes the need to learn from the past and propose a new development model. There is also a need for urban citizens to support protected areas and Indigenous peoples in the struggle to defend

[1] The Gini coefficient is a measure of income inequality, ranging from 0 (perfect equality) to 1 (maximal inequality).

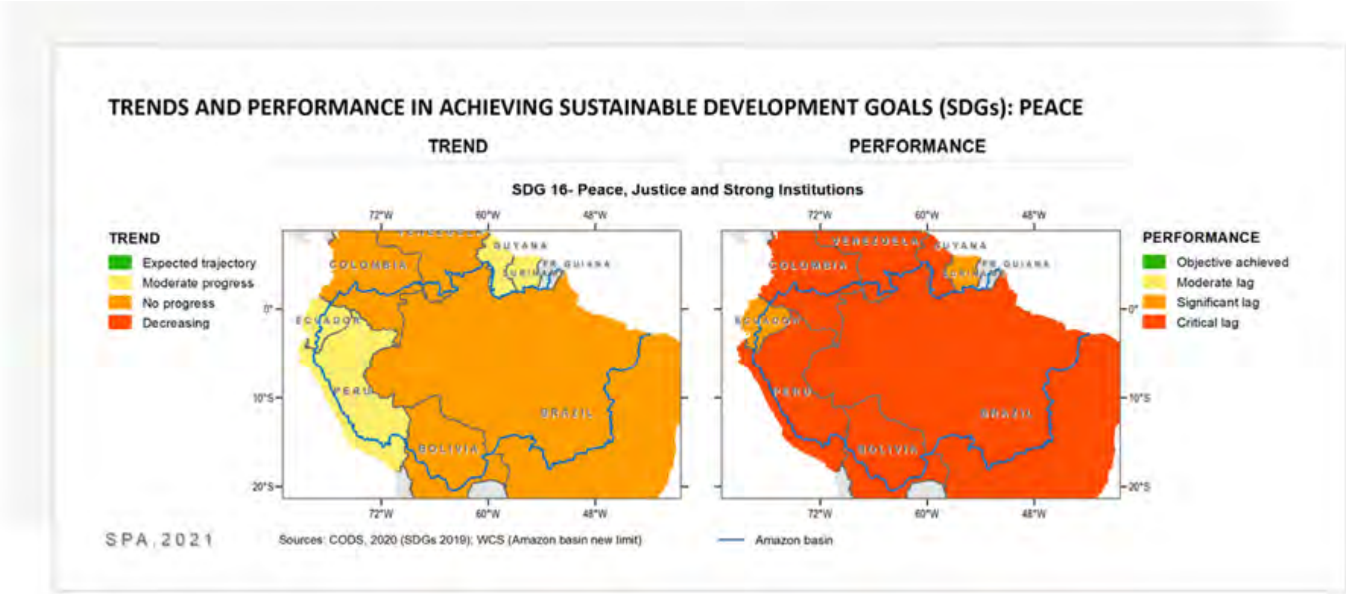


Figure 26.5 Performance and trends in achieving SDGs of the Peace dimension (based on 2019 Data CODS 2020).

their lands from encroaching development and to propose a resilient and integrated urban/rural Amazon vision (see Chapters 14, 25, and 34).

26.2.4 Peace

The 2030 Agenda text for the Peace dimension states "We are determined to foster peaceful, just and inclusive societies which are free from fear and violence. There can be no sustainable development without peace and no peace without sustainable development". SDG 16 and its targets address peace, justice, and strong institutions. All countries in the Amazon have a significant or critical lag in indicators related to safety, perception of corruption, and rule of law, and only half of countries are making moderate progress on these indicators (Figure 26.5; for details on specific indicators, see Annex 26.1).

Corruption has historically been a hurdle for Latin America, undermining growth, democracy and governance, and the rights of millions (Simon and Aalbers 2020). The region remains one of the most violent on the planet, with Venezuela having the highest number of intentional homicides per 100,000 (56.3) and Suriname the lowest (5.5) (UNODC 2020). Violence is highest in poor urban neighborhoods and on the outskirts of cities, and poverty and inequality at the local level are strong predictors of violence. These are driven by rapid and unregulated urbanization, a dearth of quality jobs, limited capacities of law-and-order institutions, and a vicious cycle of worsening quality of life and increased insecurity (Alvarado and Muggah 2018). The production, trafficking, and distribution of drugs in LAC have also driven the increase in violence in recent years.

26.2.4.1 Environmental justice, human rights and peace in the Amazon

The United Nations has drawn attention to the challenges associated with the prevention, management, and resolution of natural-resource-induced conflicts that could come to define global peace and security in the 21st century (Ban Ki-Moon 2012). Across different time periods, military, religious, commercial, and industrial ventures have looked to profit from the abundance of resources in the Amazon (see Chapters 11 and 14). Historical booms such as for rubber and Brazil nut extraction have resulted in the displacement, annihilation, and enslavement of Indigenous people. Today, the Amazon is a region with significant national and international geopolitical relevance due to the presence of strategic resources, its environmental and cultural importance, and its status as a cross-border region. The dispute over the nature and richness of the Amazon's resources has been a major factor in the emergence and maintenance of conflict.

Illegal activities such as gold mining and trafficking of drugs, humans, and wildlife occur predominantly along national borders. For example, illegal gold mining takes place mainly in river basins shared by multiple countries, such as the Putumayo and Caquetá rivers between Brazil, Colombia, Ecuador, and Peru (Heck and Tranca 2014). Ilegal gold mining is linked to the militarization of environmental management. In Colombia, the concept of "environmental security" has been inserted into the National Development Plan 2018–2022. In Peru, the national government designed a plan against illegal mining in the Amazon region of Madre de Dios with the installation of three military bases within the framework of "Operation Mercury". On the other hand, Venezuela has established a "Military Economic Zone" in the Orinoco Mining Arc, in which the armed forces are in charge of controlling and directing mining exploitation. The weak presence of the state across large parts of the Amazon makes controlling illegal activities difficult; because of this, working with local governments, communities, and Indigenous peoples to increase territorial control is an effective strategy. Preventing the impacts of mining in areas hight in biodiversity and environmental value is of the highest priority, but given the extent and impact of mining across the Basin, engaging with small-scale artisanal miners to improve their capacity for implementation of environmental and social safeguards must be considered.

Thirty years ago, constitutional reforms across the region began to recognize the multiple cultural and ethnic characteristics of their countries (Van Cott 2010). Building on these reforms, Indigenous organizations have continued to demand political inclusion and minimization of the negative effects of development in their traditional lands. They have also been behind innovations in the legal recognition of the rights of nature. The relationship between peace and the environment has led to the construction and development of notions such as environmental peace, in which it is assumed that there are clear and multiple links between armed conflict and disputes over natural resources and the environment. For example, the link between nature and peace is immersed in the Colombia Peace Agreement, forming a fundamental part of it, and is associated with the new vision for the country, which "allows the achievement of a sustainable society, united in diversity, based not only on the cult of human rights but also on mutual tolerance, on the protection of the environment, and on respect for nature, its renewable and non-renewable resources and its biodiversity" (Gobierno Nacional de Colombia and FARC-EP 2016). This link is also recognized in the constitutions of Bolivia (2009) and Ecuador (2008) in the concepts of living well, or *Sumak Kawsay*, in an approach that recognizes the importance of nature and multiculturalism for peace (Hidalgo-Capitan *et al.* 2014). However, a lack of respect for Indigenous rights continues to be an obstacle for peace in the region and threatens the integrity of collective rights and the lives of individuals. Global Witness reported 98 murders of environmentalists in the Amazon in 2019, of which 40% were Indigenous leaders. Colombia has the highest number of murders of environmental defenders in the world (64), and number are extremely high across the region, including in Brazil (24), Venezuela (8), and Peru and Bolivia (one each) (Global Witness 2020). Peace in the Amazon will not be achieved without safeguarding the environment and Indigenous rights.

26.2.5 Partnerships

The 2030 Agenda states under the Partnership dimension "We are determined to mobilize the means required to implement this Agenda through a revitalized Global Partnership for Sustainable Development, based on a spirit of strengthened global solidarity, focused in particular on the needs of the poorest and most vulnerable and with the participation of all countries, all stakeholders and all people."

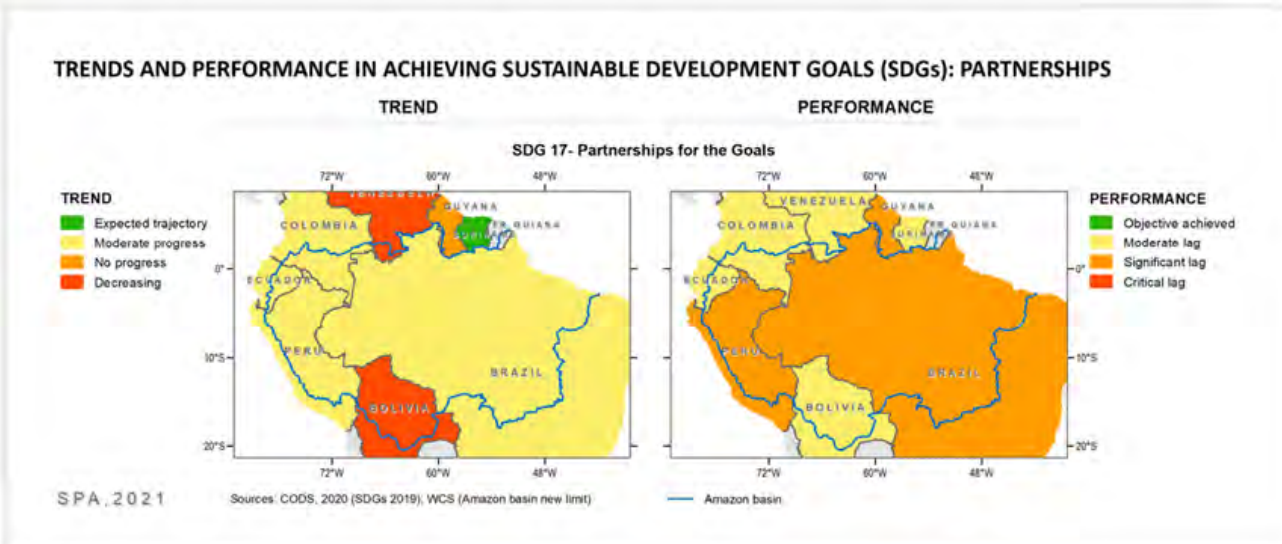


Figure 26.6 Performance and trends in achieving SDGs of the Partnerships dimension (based on 2019 Data CODS 2020).

The targets related to Partnerships aim to strengthen the means of implementation and revitalize global cooperation for sustainable development through national and international resource mobilization; develop fairer and integral policies to address national external debt and promote investment to support SDG implementation in the least developed countries; capacity building and technological cooperation and transfer through enhanced information and communication technology in support of developing countries; and equitable trade and market access. These targets also address systemic issues such as policy and institutional coherence for global macroeconomic stability, sustainable development and poverty alleviation; multi-stakeholder partnerships including public, private, and civil society to share knowledge, expertise, technology, and financial resources; and enhanced capacity for monitoring and accountability, including new indicators of progress disaggregated data by age, gender, ethnicity, and other relevant characteristics to complement existing measurements such as gross domestic product. Overall, the region shows moderate to significant lags in performance. Prior to the COVID-19 pandemic, only Suriname was on track to achieve the goal by 2030, and all the other countries were following trends that would result in moderate progress, no progress, or decreasing performance (Bolivia and Venezuela; Figure 26.6; for details on specific indicators see Annex 26.1). The impact of the COVID-19 pandemic on the economy of Suriname (Khadan 2020) is likely to have a negative impact on progress in this dimension.

Global recognition of the value of biodiversity, cultural diversity, and the environment of the Amazon Basin has led to significant international support for the region. As an example, between 2013 and 2015, approximately US $1.07 billion were invested in environmental protection, mostly by bilateral (e.g., Germany, Norway, USA) or multilateral (e.g., Global Environment Facility, Interamerican Development Bank, European Union) institutions, the Gordon and Betty Moore Foundation, Fundo Vale, and WWF (Strelneck and Vilela 2017). However, these investments are made in the context of much larger investments in unsustainable infrastructure and energy projects that drive deforestation. For example, economically unjustified road projects require an investment of US $7.6 billion and would result in the loss of 1.1 million hectares across the Amazon (Vilela *et al.* 2020). According to Fair Finance International *et al.* (2020), from 2015 to 2020, 33 major European-based financial institutions invested a combined total of US $20 billion in companies directly involved in deforestation in Brazil. These investments are made within an extractive economy responding to demands from external markets, while generating a cycle of ecosystem degradation, poverty, and reduced resilience within the Amazon.

To address these inconsistencies, a global partnership for a Living Amazon must be established and consider the critical role of the Amazon in global climate regulation. It must also consider stakeholder needs across different geographic scales and generations.

Landscape- and sub-basin-level plans represent the best opportunity to establish place-based management that considers multiple objectives and time scales. Implementation of place-based territorial plans will require partnerships between all legitimate rights holders to reach consensus around a shared vision of ecosystem integrity. Rights holders have differentiated rights and authority and may include Indigenous people on collectively held lands, agricultural communities, private natural resource management concessions, protected areas, and local governments.

At the national scale, it is vital for urban stakeholders with greater political power to support local efforts to maintain ecosystem integrity, resilient livelihoods grounded on nature-based economies, and strong participatory governance for social justice (see Figure 25.2, Chapter 25). Urban stakeholders can shift their consumption to reduce their environmental impact, support responsible markets, and exert their civil rights to demand government policies that halt deforestation and degradation and promote transparency, justice, and human rights. Government plans must also guide and support local landscape- and sub-basin-level plans to bolster human rights, including those of future generations, providing information, essential services, and resilient infrastructure. They should also promote innovation and provide incentives for sustainable — and disincentives for unsustainable — economic activities. Partnerships between different countries, such as the Leticia Pact, are particularly important to address the environmental costs of infrastructure and extractive projects across borders, and in particular across watersheds. Currently, environmental permitting mechanisms fail to incorporate landscape- and watershed-scale impacts, as well as indirect and cumulative impacts.

Partnerships are also important to address the impacts of environmental degradation on human rights and climate change, and to mobilize international resources that are commensurate with the local costs of conservation in the Amazon and the local, regional, and global benefits it generates. However, the implementation of an agreement for conservation in the Amazon will require a paradigm shift that empowers and leverages multi-cultural partnerships and those between local stakeholders, defined by cultural, terrestrial, and aquatic connectivity, within and across national borders. Progress at the bioregional level must be scaled and supported by multilevel governance at the national and Amazon Basin level in order to distribute effective application of law enforcement, policy, and financial resources. Finally, partnerships at different scales, including between the private sector, research institutes, and civil society organizations, are required to support investment, science, innovation, and research that leverages biological and cultural diversity in the region.

All countries need to recover from COVID-19. Instead of scaling back their ambitions to achieve the SDGs, the crisis can be an opportunity for transformative investment towards a more sustainable and fair future (Lancet COVID-19 Commission 2021). Access to internet connectivity for the entire Amazonian population is critical to foster innovation to achieve the SDGs.

26.3 Conclusions

The devil is in the details. Just as the 2030 Agenda highlights complementarity between different sustainable development objectives, progress in the implementation of one objective can lead to negative impacts on another (Katila *et al.* 2019). At present, policies to address hunger, access to energy, job creation, economic growth, and infrastructure can fulfill SDG targets while having a catastrophic impact on the Amazon's natural capital and, as a result, on the sustainability of these investments. In fact, the biggest threats to a resilient future in the Amazon include lowland dams, which are counted as contributing to the provision of affordable and clean energy (SDG 7); and road infrastructure (SDG 8) which fuels agricultural expansion (SDG 2). Similarly, there can be trade-offs or synergies between life on land (SDG 15) and decent work and economic growth (SDG 8).

The future of Amazonian countries and other countries around the world ultimately depends on the availability of global natural resources and biodiversity, and on the sustainable use of these resources within the Basin. In 2019, United Nations Deputy Secretary-General Amina Mohammed opened a senior-level meeting of the Global Partnership for Effective Development Cooperation, in New York, by recognizing that there is a long way to go to achieve the SDG targets due to siloed approaches, making a call for new approaches. Amazonian countries can propose a new approach to development that maintains ecological integrity and diversity, social justice and rights, and economic prosperity and equity (see Chapter 25). This transformation towards a Living Amazon requires international financial support and regional partnerships. However, implementation occurs at a landscape or watershed level, where disaggregated information can reduce trade-offs and leverage synergies of the needs of different genders, ethnicities, and generations. Leveraging local knowledge and agency at the landscape or watershed scale also ensures ownership and accountability.

International and national policies that provide incentives for sustainability standards in the private sector can also help minimize trade-offs and maximize synergies amongst the different SDGs. National policies and investments also have severe impacts, and regional and global agreements must include clear and binding agreements to prevent negative consequences.

In order to respect the ecological limits to disturbance of the Amazon Basin, 80% of forest cover must be maintained in a matrix where pristine or near-pristine landscapes hold the greatest environmental and cultural values and include protected areas, Indigenous territories, and fiscal lands that require policies to secure their management and guarantee their existence in perpetuity. The costs of conserving these areas must be recognized, based on their role in conserving a healthy planet. On the other hand, these pristine or near-pristine areas are surrounded by areas with different levels of degradation. Incentives must be shifted from an extractive-based economy to a nature-based economy, supporting restoration and management in ways that are consistent with sustainable production to reduce the pressure of the farming and ranching frontier into healthy ecosystems (see Chapters 25, 27–30). Equally important is reducing subsidies for the palm oil, timber, soy, beef, and biofuels sectors. Payment programs and land-use taxes on agricultural land can be effective and less costly than command-and-control interventions (Souza-Rodrigues 2019). There is an urgent need for an integrated public policy response in Amazonian countries to overcome the COVID-19 pandemic with a sustainable and equitable recovery; this includes fostering intersectoral public action, regional integration, and international solidarity and cooperation to achieve the 17 SDGs, placing the most vulnerable at the center of the policy response (León and Cárdenas 2020).

In the post-pandemic future, it is imperative to think about opportunities to build more effective, equitable, and resilient health, environmental, economic, and social systems. Energy transitions towards renewable sources and reduction in the consumption of fossil fuels, sustainable mobility with inclusive urban policies, universal access to digitalization, development of the healthcare manufacturing industry, development of a sustainable bioeconomy, promoting a circular economy, and sustainable tourism are strategic sectors that have the potential to support a greener, more inclusive, and transformative recovery (ECLAC 2021b). Advancing the 2030 Agenda requires long-term investments, the recapture of employment with digital change, implementation of policy to support innovation and technology, promotion of sustainable consumption patterns, and resilient, impact-based value chains that offer a social, economic, and environmental response at the personal, local, and regional level to address the climate change, biodiversity, and pandemic crises (Gonzalez-Perez *et al.* 2021).

26.4 Recommendations

- Establish a Global Partnership for a Living Amazon to channel financial and technical resources that are commensurate with the global importance of the Basin for climate change, regional hydrological systems, and a healthy planet.
- Localize goals, targets, and indicators to implement the 2030 Agenda at a landscape and watershed scale, including self-determined Life Plans.
- Ensure alignment of international finance and markets with the 2030 Agenda for a Living Amazon by establishing and enforcing standards of true cost accounting of development projects, and measure and mitigate the material footprints of countries that receive resource flows from the Amazon.
- Promote a green, inclusive, and transformative post-COVID-19 recovery, placing the most vulnerable at the center of an integrated policy response based on rights, incentives, digitalization, innovation, technology, and sustainable production and consumption.

26.5 References

Abeles M, Caldentey EP, and Porcile G. 2020. The COVID-19 crisis and the structural problems of Latin America and the Caribbean: responding to the emergency with a long-term perspective. *CEPAL Review* **132**.

Alvarado N and Muggah R. 2018. Crime and Violence. Obstacles to Development in Latin American and Caribbean Cities. Discussion Paper No. IDB-DP-644. Inter-American Development Bank: Washington, DC.

Ban Ki-Moon. 2012. Día para la Prevención de la Explotación del Medio Ambiente en la Guerra y los Conflictos Armados, 6 de noviembre. Available at: https://www.un.org/es/events/environmentconflict-day/2012/sgmessage.shtml. Accessed on: 20 Apr 2021.

Bennett-Curry A, Malhi Y, and Menton M. 2013. Leakage effects in natural resource supply chains: a case study from the Peruvian commercial charcoal market. *Int J Sustain Dev World Ecol* **20**: 336–48.

Boers N, Marwan N, Barbosa HMJ, and Kurths J. 2017. A deforestation-induced tipping point for the South American monsoon system. *Sci Rep* **7**: 1–9.

Brazil. 2021. Resumo de Registro de Agrotóxicos, Componentes e Afins. Ministério da Agricultura, Pecuária e Abastecimento – MAPA. Available at: https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-agricolas/agrotoxicos/informacoes-tecnicas, Accessed on 1 Nov. 2021.

CEPAL. 2019a. Informe de avance cuatrienal sobre el progreso y los desafíos regionales de la Agenda 2030 para el Desarrollo Sostenible en América Latina y el Caribe. Available at: https://www.cepal.org/es/publicaciones/44551-informe-avance-cuatrienal-progreso-desafios-regionales-la-agenda-2030-desarrollo

CEPAL. 2019b. ODS 6: Garantizar la disponibilidad y la gestión sostenible del agua y el saneamiento para todos en América Latina y el Caribe. In: Tercera Reunión del Foro de los Países de América Latina y el Caribe sobre el Desarrollo Sostenible, convocada bajo los auspicios de la Comisión Económica para América Latina y el Caribe (CEPAL) en Santiago del 24 al 26 de abril de 2019. Santiago.

CEPAL. 2021. Observatorio COVID-19 en América Latina y el Caribe Impacto económico y social. Available at: www.cepal.org/es/temas/covid-19.

Climate Watch. Climate Watch platform. Available at: https://www.climatewatchdata.org/.

CODS. 2020. Índice ODS 2019 para América Latina y el Caribe.

Collen W. 2016. The Amazon and Agenda 2030. UNDP United Nations Dev Program: 40.

Contreras-Urbina M, Bourassa A, Myers R, *et al.* 2019. Guyana Women's Health and Life Experiences Survey. UN Women.

Dasgupta, P. 2021. The Economics of Biodiversity: The Dasgupta Review. London: HM Treasury.

Davies R and Smith W. 1998. The Basic Necessities Survey: The Experience of Action Aid Vietnam. London: Action Aid.

Devereux S, Béné C, and Hoddinott J. 2020. Conceptualising COVID-19's impacts on household food security. *Food Secur* **12**: 769–72.

DFID. 2000. Achieving Sustainability: Poverty Elimination and the Environment. Department for International Development.

Dourojeanni Ricordi AC. 2020. Sistemas de gestión de las intervenciones en las cuencas. Available at: https://www.iagua.es/blogs/axel-charles-dourojeanni-ricordi/sistemas-gestion-intervenciones-cuencas. Accessed on: 20 Apr 2021.

ECLAC. 2021a. Social Panorama of Latin America 2020 (LC/PUB.2021/2-P/Rev.1). Santiago, 258p.

ECLAC. 2021b. Building forward better: action to strengthen the 2030 Agenda for Sustainable Development (LC/FDS.4/3/Rev.1). Santiago.

ECLAC-CEPALSTAT. 2021. Statistics and Indicators (database). Economic Commission for Latin America and the Caribbean. Available at: https://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/estadisticasIndicadores.asp?idioma=i

ECLAC and ILO. 2018. Environmental sustainability and employment in Latin America and the Caribbean. Employment Situation in Latin America and the Caribbean **19** (LC/TS.2018/85), Santiago

FAO. 2015. Food Losses and Waste in Latin America and the Caribbean. The countries of the region are progressing towards a future with less Food Losses and Waste. Bulletin no. 2, 39p.

Fabregat-Safont D, Ibáñez M, Bijlsma L, *et al.* 2021. Wide-scope screening of pharmaceuticals, illicit drugs and their metabolites in the Amazon River. *Water Res* **200**: 117251.

Fair Finance International, Instituto Brasileiro de Defesa do Consumidor & Sweden Sverige. 2020. Financiamentos e investimentos no desmatamento da Amazônia e do Cerrado. São Paulo. Available at: https://guiadosbancosresponsaveis.org.br/media/496265/estudo_amazonia_e_cerrado_gbr_2020.pdf

Fath BD, Fiscus DA, Goerner SJ, *et al.* 2019. Measuring regenerative economics: 10 principles and measures undergirding systemic economic health. *Glob Transitions* **1**: 15–27.

Fellows M, Paye V, Alencar A, *et al.* 2021. Under-Reporting of COVID-19 Cases Among Indigenous Peoples in Brazil: A New Expression of Old Inequalities. *Front Psychiatry* **12**.

Ferrante L and Fearnside PM. 2019. Brazil's new president and 'ruralists' threaten Amazonia's environment, traditional peoples and the global climate. *Environ Conserv* **46**: 261–3.

Fundación Aquae. 2017. Agua Limpia y Saneamiento en la Amazonia Peruana. Available at: https://www.fundacionaquae.org/wp-content/uploads/2017/06/comic-proyecto.pdf. Viewed

Global Witness. 2020. Defending tomorrow: The climate crisis and threats against land and environmental defenders. Available at: file:///Users/isabellatemp/Downloads/Defending_Tomorrow_EN_high_res_-_July_2020.pdf

Gobierno Nacional de Colombia y Fuerzas Armadas Revolucionarias de Colombia-Ejército del Pueblo F-E. Acuerdo final para la terminación del conflicto y la construcción de una paz estable y duradera. Proceso constituyente fragmentado. Un nuevo pacto o contrato social para la paz: 3–4.

Gonzalez-Perez MA, Mohieldin M, Hult GTM, and Velez-Ocampo J. 2021. COVID-19, sustainable development challenges of Latin America and the Caribbean, and the potential engines for an SDGs-based recovery. *Manag Res J Iberoam Acad Manag* **19**: 22–37.

Gutiérrez Montes I, Siles J and Aguilar AE. 2009. Diagnóstico de medios de vida y capitales de la comunidad: Humedales de Medio Queso Los Chiles, Costa Rica. MONTES DE OCA, Costa Rica: Unión Internacional para la Conservación de la Naturaleza

Heck C and Tranca J. 2014. La realidad de la minería ilegal en países amazónicos. Sociedad Peruana de Derecho Ambiental. Available at: https://illegalmining.amazoniasocioambiental.org/La-realidad-de-la-mineria-ilegal-en-paises-amazonicos-SPDA-d891b11c9433fe22ae037fca2a0d7cd5.pdf?lang=en

Hidalgo-Capitán AL, Arias A, and Ávila J. 2014 (Eds.). Sumak Kawsay Yuyay Antología del pensamiento indigenista ecuatoriano sobre Sumak Kawsay. Huelva y Cuenca, cim / pydlos / fiucuhu, 367 pp, ISBN 978-84-616-8167-9.

INPE-PRODES. 2021. Monitoring Deforestation of the Brazilian Amazon Forest by Satel-lite. Available at: http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes

Khadan J. 2020. Suriname in times of COVID- 19: navigating the labyrinth. IDB Technical Note No. 2025.

Iorio P and Sanin ME. 2019. Acceso y asequibilidad a la energía eléctrica en América Latina y El Caribe. Inter-American Development Bank.

Katila P, Pierce Colfer CJ, Jong W de, *et al.* (Eds). 2019. Sustainable Development Goals: Their Impacts on Forests and People. Cambridge University Press.

Koenig K. 2019. The Amazon Sacred Headwaters: Indigenous Rainforest "Territories for Life" Under Threat. Available at: https://amazonwatch.org/news/2019/1209-the-amazon-sacred-headwaters

Lancet COVID-19 Commission. 2021. Transforming Recovery into a Green Future. Statement of the Lancet COVID-19 Commission task force on Green Recovery.

Lehm Z. 2019. Wildlife Conservation Society: 20 años de trabajo con pueblos indígenas y comunidades locales para la conservación de la vida silvestre en la Amazonía Andina. Wildlife Conservation Society.

León DC and Cárdenas JC. 2020. Lessons from COVID-19 for a Sustainability Agenda in Latin America and the Caribbean. UNDP LAC C19 PDS n. 14A: 1–35.

Lovejoy TE and Nobre C. 2019. Amazon tipping point: Last chance for action. *Sci Adv* **5**: eaba2949.

Mansur AV, Brondízio ES, Roy S, *et al*. 2016. An Assessment of Urban Vulnerability in the Amazon Delta and Estuary: A multi-Criterion Index of Flood Exposure, Socio-Economic Conditions and Infrastructure. *Sustainability Sciences*:1-16, doi:10. 1007/ s11625-016-0355-7.

Mills E. 2015. The Bioeconomy: A Primer. Transnational Institute. Hands on the Land Coalition. Available from: www.tni.org/en/publication/the-bioeconomy.

Muruzábal C. 2018. For Latin America to thrive in the digital era, it must first teach minds, then the machines. World Economic Forum. Available at: https://www.weforum.org/agenda/2018/03/here-s-how-latin-america-can-thrive-in-the-digital-era/.

NDC Partnership. 2018. NDC Partnership Work Program 2018-2020.

Nobre CA, Sampaio G, Borma LS, *et al.* 2016. Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. *Proc Natl Acad Sci* **113**: 10759–68.

Novta N and Wong JC. 2017. Women at Work in Latin America and the Caribbean. IMF Working Papers.

OEP and BID. 2021. Gestión sostenible de plásticos. Análisis regulatorio y técnico en el marco de la Iniciativa de Economía Circular en la Alianza del Pacífico y Ecuador. Observatorio

Estratégico de la Alianza del Pacífico y BID.
OTCA/PNUMA/OEA. 2006. Proyecto manejo integrado y sostenible de los recursos hídricos transfronterizos en la cuenca del río Amazonas considerando la variabilidad climatica y el cambio climatico. Repos Inst - ANA: 1–116.
Piachaud D. 1987. Problems in the Definition and Measurement of Poverty. *J Soc Policy* **16**: 147–64.
Vallejos PQ, Veit P, Tipula P, and Reytar K. 2020. Undermining Rights: Indigenous Lands and Mining in the Amazon. World Resources Institute.
RAISG. 2019. Amazonia 2019 – Protected Areas and Indigenous Territories. Available at: https://www.amazoniasocioambiental.org/en/maps/.
Rocha-Román L, Olivero-Verbel J, and Caballero-Gallardo KR. 2018. Impacto de la minería del oro asociado con la contaminación por mercurio en suelo superficial de San Martín de Loba, Sur de Bolívar (Colombia). *Rev Int Contam Ambient* **34**: 93–102.
Roux AVD, Bilal U, Kephart JL, *et al.* 2021. COVID-19 and urban health in Latin America and the Caribbean a challenge for urban health and health equity.
Salinas ER, Wallace L, Painter Z, *et al.* 2017. The environmental, economic and sociocultural value of indigenous territorial management in the Greater Madidi Landscape. La Paz.
Samaniego J, Alatorre JE, Reyes O, *et al.* 2019. Panorama de las contribuciones determinadas a nivel nacional en América Latina y el Caribe, 2019: avances para el cumplimiento del Acuerdo de París. Available at: https://www.cepal.org/es/publicaciones/44974-panorama-contribuciones-determinadas-nivel-nacional-america-latina-caribe-2019
Santos D, Mosaner M, Celentano D, *et al*. 2018. Índice de Progresso Social na Amazônia brasileira: IPS Amazônia.
Santos RE, Pinto-Coelho RM, Drumond MA, *et al*. 2020. Damming Amazon Rivers: Environmental impacts of hydroelectric dams on Brazil's Madeira River according to local fishers' perception. *Ambio* **49**: 1612–28.
Schreckenberg K, Poudyal M, and Mace G. 2018. Ecosystem services and poverty alleviation: trade-offs and governance. Taylor & Francis, 352p.
Simon R and Aalbers G. 2020. The Capacity to Combat Corruption (CCC) Index: Assessing Latin America's ability to detect, punish and prevent corruption amid COVID-19.
Souza-Rodrigues E. 2019. Deforestation in the Amazon: A Unified Framework for Estimation and Policy Analysis. *Rev Econ Stud* **86**: 2713–44.
Strelneck D and Vilela T. 2017. International conservation funding in the Amazon: An updated analysis. Gordon and Betty Moore Foundation, Palo Alto, California.
UCLG. 2018. Ciudades Amazónicas: Aprendizaje entre pares sobre el uso sostenible de los ecosistemas terrestres. Available at: https://www.uclg.org/en/node/29461
United Nations. 2015. Transforming our world: the 2030 Agenda for Sustainable Development. Department of Economic and Social Affairs. United Nations General Assembly.
UNIDO. 2015. Inclusive and Sustainable Industrial Development in Latin America and Caribbean Region. United Nations Industrial Development Organization.
UN Water. 2020. Indicator 6.5.1 "Degree of integrated water resources management implementation (0-100)". Available at: https://www.sdg6monitoring.org/indicator-651/. Accessed on: 31 Mar 2021.
UNDP. 1990. Human Development Report 1990: Concept and Measurement of Human Development. Available at: http://www.hdr.undp.org/en/reports/global/hdr1990.
UNDP. 2020. The Next Frontier: Human Development and the Anthropocene. 2020 Human Development Report.
UNDP and UN-Habitat. 2016. Roadmap for localizing the SDGs: implementation and monitoring at subnational level. Available at: https://unhabitat.org/roadmap-for-localizing-the-sdgs-implementation-and-monitoring-at-subnational-level
UNEP. 2020. Emissions Gap Report. United Nations Environment Programme.
UNFCCC. 2021. INDCs as communicated by Parties. Available at: https://www4.unfccc.int/sites/submissions/INDC/Submission Pages/submissions.aspx.
UNODC. 2020. UN Office on Drugs and Crime's International Homicide Statistics database. Available at: https://www.unodc.org/unodc/en/data-and-analysis/statistics.html. Viewed 31 Mar 2021.
Van Cott DL. 2010. Indigenous Peoples' Politics in Latin America. *Annu Rev Polit Sci* **13**: 385–405.
Verrest H. 2007. Home-based economic activities and Caribbean urban livelihoods: Vulnerability, ambition and impact in Paramaribo and Port of Spain. Amsterdam University Press.
Vilela T, Malky Harb A, Bruner A, *et al.* 2020. A better Amazon road network for people and the environment. *Proc Natl Acad Sci* **117**: 7095–102.
WCS. 2016. Mapeo cultural, espiritual, territorial del Pueblo Kukama (Bajo río Marañón). Available at: https://peru.wcs.org/es-es/WCS-Peru/Noticias/articleType/ArticleView/articleId/9297/Mapeo-cultural-espiritual-territorial-del-Pueblo-Kukama-Bajo-rio-Maranon.aspx. Accessed on: 31 Mar 2021.
WHO and UNICEF. 2019. Progress on household drinking water, sanitation and hygiene 2000-2017WHO/UNICEF Joint Monitoring Program for Water Supply, Sanitation and Hygiene.
World Bank. 2020. GDP per capita Latin America. Available at: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=ZJ
World Bank. 2015. Indigenous Latin America in the twenty-first century: the first decade. Washington, D.C.
World Bank. 2021a. Acting now to protect the human capital of our children: The costs of and response to COVID-19 pandemic's impact on the education sector in Latin America and the Caribbean. World Bank, Washington DC.
World Bank. 2021b. GINI index – World bank estimate. Available at: https://data.worldbank.org/indicator/SI.POV.GINI.
World Water Week. 2020. No Amazonia, no water: climate change in the rainforest. Available at: https://www.worldwaterweek.org/event/9163-noamazonia-no-water-climate-change-in-the-rainforest

Amazon Assessment Report 2021

Chapter 27

Conservation measures to counter the main threats to Amazonian biodiversity

Grande área de garimpo com dezenas de barracões, rio Uraricoera, Terra Indígena Yanomami
(Foto: Bruno Kelly/Amazônia Real)

INDEX

KEY MESSAGES 3
ABSTRACT 3
27.1 INTRODUCTION 4
27.2 HABITAT LOSS AND ECOSYSTEM DEGRADATION RESULTING FROM CATTLE RANCHING, CROPLAND EXPANSION, AND LAND SPECULATION 4
27.3 ECOSYSTEM DEGRADATION RESULTING FROM BIOLOGICAL RESOURCE USE: OVEREXPLOITATION OR RESOURCES BY HUNTING, FISHING AND LOGGING 5
27.3.1 Hunting 5
27.3.2 Overfishing 5
27.3.3 Illegal wildlife trade 6
27.3.4 Illegal logging 6
27.4 ECOSYSTEM DEGRADATION RESULTING FROM CLIMATE CHANGE & SEVERE WEATHER 7
27.5 INFRASTRUCTURE AS A DRIVER OF CHANGE: ROADS AND RAILWAYS 7
27.6 ENERGY AND MINING AS A DRIVER OF CHANGE 8
27.7 INVASIVE SPECIES AND DISEASES 8
27.8 HUMAN INTRUSIONS: WAR AND UNREST 9
27.9 AGRICULTURAL, AQUACULTURAL, AND INDUSTRIAL WASTE; PLASTIC WASTE; HEAVY METALS AND MERCURY 10
27.10 SMALL DAMS CREATED BY AGRICULTURE AND ROAD INFRASTRUCTURE 10
27.11 ECOSYSTEM DEGRADATION RESULTING FROM INTERACTIONS BETWEEN STRESSORS 11
27.12 CONCLUSIONS 12
27.13 REFERENCES 12

Graphical Abstract

Figure 27.A Graphical Abstract

Conservation Measures to Counter the Main Threats to Amazonian Biodiversity

Jos Barlow[a], Alexander C. Lees[b], Plinio Sist[cd]*, Rafael Almeida[e], Caroline Arantes[f], Dolors Armenteras[g], Erika Berenguer[a,h], Patrick Caron[d], Francisco Cuesta[i], Carolina Doria[j], Joice Ferreira[k], Alexander Flecker[e], Sebastian Heilpern[l], Michelle Kalamandeen[m], Marielos Peña-Claros[n], Camille Piponiot[o], Paulo Santos Pompeu[p], Carlos Souza[q], Judson F. Valentim[r]*

Key Messages

- The Amazon's biodiversity and ecosystem functioning are threatened by a broad range of threats originating within the basin and worldwide. These include habitat loss from the expansion of cattle ranching and croplands, hunting and overfishing, climate change, inappropriate infrastructure, mining and energy generation, invasive species, war and unrest, pollution, and the fragmentation of watercourses by small dams and impoundments.
- Threats often co-occur in the same regions; interactions between them can amplify their effects or create new problems. Given the range of threats and their complexity, there is no single or simple solution to solve the Amazon's socio-environmental problems. Instead, a broad set of initiatives need to be (re)adopted, replicated, and scaled up.
- Achieving wide-ranging conservation measures will require actions that go beyond the traditional remit of conservation biology. It will require a new vision for the Amazon's people and nature, and investment in alternative economic strategies.
- Actions taken within the Amazon must be accompanied by changes in non-Amazonian countries and regions, to limit climate change and avoid exporting deforestation, river fragmentation, and other environmental harms.

Abstract

Present-day human activities are reducing and altering Amazonian biodiversity and disrupting the functioning of terrestrial and aquatic ecosystems (Chapter 19 & 20). This chapter outlines some of the approaches required to address the main threats to the Amazon's biodiversity and ecosystems, i.e.,

[a] Lancaster Environment Centre, Lancaster University, Lancaster, UK, jos.barlow@lancaster.ac.uk
[b] Department of Natural Sciences, Manchester Metropolitan University, UK
[c] Agricultural Research Centre for International Development – France. CIRAD, sist@cirad.fr.
[d] Université de Montpellier, UR Forests & Societies, Montpellier 34398, France
[e] Department of Ecology and Evolutionary Biology, Cornell University, 616 Thurston Ave., Ithaca NY 14853, USA
[f] Center for Global Change and Earth Observations, Michigan State University, East Lansing, USA
[g] Departamento de Biología, Facultad de Ciencias, Universidad Nacional de Colombia, Bogotá, Colombia.
[h] Environmental Change Institute, University of Oxford, Oxford, UK.
[i] Grupo de Investigación en Biodiversidad, Medio Ambiente y Salud - BIOMAS - Universidad de Las Américas (UDLA), Quito, Ecuador
[j] Laboratório de Ictiologia e Pesca, Departamento de Ciências Biológicas, Universidade Federal de Rondônia (UNIR), Porto Velho, Brazil
[k] Embrapa Amazonia Oriental, Trav. Eneas Pinheiro, Belém, Brazil
[l] Department of Natural Resources, Cornell University, USA
[m] School of Geography, University of Leeds, Leeds, UK
[n] Forest Ecology and Forest Management Group, Wageningen University & Research, Wageningen, The Netherlands
[o] Smithsonian Conservation Biology Institute & Smithsonian Tropical Research Institute, Republic of Panama
[p] Departamento de Ecologia e Conservação, Instituto de Ciências Naturais, Universidade Federal de Lavras, Lavras, MG, Brazil.
[q] Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), Belém, PA, Brazil.
[r] Agroforestry Research Center of Acre, Embrapa Acre, Rodovia BR-364, Km 14 (Rio Branco/Porto Velho), Rio Branco AC 69900-970, Brazil

deforestation, damming of rivers, mining, hunting, illegal trade, drug production and trafficking, illegal logging, overfishing, and infrastructure expansion. The role of restoration is addressed in Chapters 28 and 29.

Keywords: *Deforestation, degradation, dams, mining, hunting, fishing, logging*

27.1 Introduction

The Amazon's biodiversity and ecosystem functioning are threatened by a broad range of drivers originating within the basin and worldwide. Here we outline some of the preventative measures required to counter the most important threats to Amazonian biodiversity, using an Amazon-specific adaptation of the International Union for Conservation of Nature (IUCN) Threats Classification Scheme (v 3.2) as the framework for analysis of drivers of change (https://www.iucnredlist.org/resources/threat-classification-scheme). As this is a high-level review, it is important to clarify that not all threats are equally relevant across the basin (See Chapters 19 and 20), that the solutions presented here are higher-level and do not explore the nuances and details that are key to implementation in specific regions or contexts, and that conservation measures that may work in one country or setting may be ineffective or counter-productive elsewhere. Finally, we note that measures to conserve Amazonian biodiversity must be carried out alongside a broader set of measures that protect vulnerable people, and enhance well-being and local livelihoods (e.g. see also Chapters 25, 26, 30, and 31).

27.2 Habitat loss and ecosystem degradation resulting from cattle ranching, cropland expansion, and land speculation

Deforestation, forest degradation, and the conversion of non-forest ecosystems threaten native biodiversity across the Amazon (Chapter 19). Where deforestation is the major threat, conservation actions can be developed around the adoption, replication, or return to interventions that were successful in the past or in other regions. These include (i) near-real-time monitoring of forest loss across the basin, (ii) effective on-the-ground enforcement actions, (iii) use of sanctions as allowed under environmental laws and credit restrictions for landholders in high deforestation zones, (iv) soy and cattle moratoria, (v) incentives for agricultural systems that avoid deforestation, (vi) the expansion, legal demarcation, and genuine safeguarding of protected areas, including sustainable use reserves and Indigenous territories, (vii) support for and recognition of grassroots actions including community led patrols and mapping, and (viii) incentive-based mechanisms, such as payments for ecosystem services and voluntary REDD+ schemes, to maintain forest cover and avoid degradation on private lands.

Advancements in remote sensing can greatly support these interventions, allowing for real-time, finer scale, and higher-temporal resolution assessments of forest loss and an improved ability to track drivers of degradation such as fire and illegal logging. Remote sensing also needs to track the loss and degradation of non-forest ecosystems, which can be much harder to detect.

The success of interventions designed to prevent deforestation and degradation require better governance and reduced corruption at all scales (Cuneyt Koyuncu and Rasim Yilmaz, 2008; Fischer et al., 2020). Evaluating the conservation of native vegetation on private lands requires up-to-date and transparent land registries (e.g., the *Cadastro Ambiental Rural*in Brazil). Reducing the negative impact of commodities that are strongly associated with deforestation such as beef, soy, and minerals. requires full accounting of supply chains to remove deforestation (Zu Ermgassen et al., 2020). In addition to actions within Amazonian countries, improving governance and financial accountability also depends on actions in countries that import Amazonian products.

27.3 Ecosystem degradation resulting from biological resource use: overexploitation or resources by hunting, fishing and logging

27.3.1 Hunting

Hunting of wildlife is widespread, culturally embedded in the Amazon, and represents a major threat to some Amazonian vertebrates and, ultimately, ecosystems (Chapter 19). For species such as the Endangered Wattled Curassow (*Crax globulosa*) it is the preeminent threat, whilst for others like the Critically Endangered Black-winged Trumpeter (*Psophia obscura*) it acts in synergy with habitat loss, fragmentation, and degradation. Effective enforcement of existing legal instruments to protect threatened species from hunting is crucial for the long-term persistence of such species. In some cases this may be a matter of effective outreach to counter ignorance of laws or the high social acceptability of illegal actions (Winter and May, 2001). However, conservation intervention strategies need to take into account the potentially serious impacts on many local peoples who are at risk of loss of culture, traditional knowledge, and dietary diversity leading to risks to food security (Ibarra et al., 2011). Although much hunting is for subsistence purposes and is tied to rural poverty, hunting does cross socio-economic boundaries (El Bizri et al., 2015) and may be facilitated by a lack of enforcement – encouraging non-compliance for economic gain or simply social enjoyment and/or prestige. Urban demand for bushmeat is high (Parry et al., 2014), and is an important driver of game species depletion, even in high forest cover landscapes (Parry and Peres, 2015).

Bragagnolo et al. (2019) drew up a series of recommendations to mitigate the impact of hunting while considering human well-being. They suggest that i) the process of registering to become a subsistence hunter needs to be simplified, ii) licensing schemes should be extended, and iii) hunting needs to be linked to community-based wildlife management. Management of harvested wildlife should ideally be based on quota systems which consider variation in the life history attributes of different game species, including reproductive rates and population density. Additionally, or alternatively, the creation of 'no-take zones' which foster source-sink dynamics are another well-established strategy to avoid regional game depletion (Wilkie and Carpenter, 1999). No-take zones may be specific to certain habitats, for example restricting hunting to secondary forest zones embedded in primary forest matrices (Garcia-Frapolli et al., 2007), although they would require compliance to be effective. In circumstances where illegal hunting needs to be controlled and hunting pressure reduced, potential interventions include i) the provision for alternative livelihoods, ii) modification of game supply chains through substitution, and iii) utilising education and social marketing campaigns to target key demographics for behaviour change (Bragagnolo et al. 2019).

27.3.2 Overfishing

Fishing in the Amazon embraces a gradient of intensity, from industrial to artisanal, and uses diverse gear and techniques, with impacts that vary spatiotemporally across different river ecosystems. This can lead to the depletion of stocks, but as with hunting, it disproportionately affects some species more than others, with the greatest impacts on large-bodied fish (Chapter 20). Many large-bodied species are also migratory, posing transboundary management challenges. Many of the solutions to overharvesting of terrestrial vertebrates apply equally to fisheries, with a focus on integrated fishery management that may include community-based planning, careful stock assessments which consider species' life histories, the implementation of no-take areas, and control of commercial activities. Community co-management schemes, in particular, have proven to be effective in reducing pressure on key species, safeguarding aquatic biodiversity, improving people's livelihoods through increased yields, and empowering marginalized groups, including women and Indigenous peoples (Silva and Peres 2016, Lopes et al. 2021). Enforcement of existing closed season limits and minimum size requirements would increase population productivity, limit overexploittation (Castello et al., 2011), and protect sexually immature individuals to guard against the collapse of fish stocks, even if fishing is curtailed (Myers and Mertz, 1998). Diversification of the catch composition ought to reduce pressure on overexploited species; this is particularly the case for migratory species like *Salminus brasiliensis*, *Colossoma macropomum*, *Brachyplatystoma capapretum* and *Pseudoplatystoma* spp. which need effective management at large spatial scales. Other 'fishing' activities need to be ended immediately; for example, population declines in the Amazonian freshwater dolphins *Inia geoffrensis* and *Sotalia fluviatilis* are due to a combination of bycatch and fishing that uses them as bait to catch the scavenging catfish *Calophysus macropterus* (da Silva et al. 2018). The pervasive lack of long-term monitoring is a major barrier to quantify and mitigate overfishing. National governments from across the Amazon need to invest in regional infrastructure to collect, maintain, and share tinformation (Goulding et al. 2019).

27.3.3 Illegal wildlife trade

Although the prevalence may have declined from historical highs, domestic and international trafficking remains the main driver of decline for aquatic species such as ornamental fish (Chapter 20) and terrestrial species such as songbirds (Chapter 19). For example, the population of the Great-billed Seed-Finch *Sporophila maximiliani* is Critically Endangered in Brazil but it is still encountered in trade (do Nascimento et al., 2015; Machado et al., 2019). Authorities need also to be vigilant about new trades; there is now an emerging market for felid body parts, driven in part by demand for their use in Chinese traditional medicine (Morcalty et al. 2020). Enforcement agencies have seized Jaguar (*Panthera onca*), Puma (*Puma concolor*) and Ocelot (*Leopardus pardalis*) remains, most apparently sourced from Bolivia (Arias et al. 2021). Addressing international trade requires improvements in the funding of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (Phelps et al., 2010). Additional measures could help mitigate the effects of biodiversity trafficking. For example, the foundation of pedigree-controlled captive lineages from the last wild birds, or from wild birds confiscated by environmental authorities, could help ensure the genetic integrity of some of the most threatened species (Ubaid et al., 2018). This should be in addition to efforts to stop the trade in wild birds entering, and measures to increase the sustainability of bird-keeping through emphasizing the importance of captive-bred birds (Marshall et al., 2020). All conservation interventions will be more effective if actions are taken to reduce domestic and foreign demand for wild species.

27.3.4 Illegal logging

In the absence of strict regulation and monitoring, selective logging can be a major driver of forest degradation, weakening forest resilience to fires (Alencar et al., 2004), increasing the risk of commercial extinction of the most valuable timber species (Blundell and Gullison, 2003; Branch et al., 2013; Richardson and Peres, 2016), and reducing the richness and altering the composition of forest fauna (e.g. Mason 1996, Barlow et al. 2006, França et al. 2018). Selective logging is also an important indirect driver of deforestation, creating roads, access, and settlements (Chapter 19). There is a wealth of evidence on effective regulatory solutions, such as timber harvesting guidelines that set offtake limits, avoiding logging in ecologically sensitive areas such as steep slopes and adjacent to watercourses, and ways to mitigate the impacts of tree felling, yarding, and hauling. These are collectively known as "reduced-impact logging" (RIL) techniques (ITTO/IUCN, 2009; ITTO, 2015). While these are undoubtedly preferable to conventional (unplanned) approaches in reducing losses of carbon and biodiversity (West et al., 2014; Chaudhary et al., 2016), there are still important concerns about the long-term sustainability of the harvest rates that have been set (Sist et al., 2021). These need to be revisited using species- and region-specific data from repeated harvests and modeling studies (Sist and Ferreira, 2007; Piponiot et al., 2019). The greatest and most immediate challenge relates to the high prevalence of illegal activities, which even permeate legal concessions (Finer et al., 2014; Brancalion et al., 2018). Illegal logging has two main effects. First, sustainable forest management practices will not be followed in the areas where timber is illegally extracted (Vidal et al., 2020), causing significant and long-lasting reductions in forest carbon stocks (Berenguer et al., 2014). Second, the availability of illegal timber suppresses market prices, reducing incentives for others to follow RIL methods (Santos de Lima et al., 2018).

Addressing these issues will require improved public systems governing logging, and more transparent supply chains so that the origin of timber can be clearly traced and verified (Brancalion et al. 2018). Big data, use of unmanned aerial vehicles (UAV) (Figueiredo et al., 2016), and DNA technologies could support verification processes (Degen et al., 2013). Improvements can also be made by creating stronger forest-related partnerships between multiple actors, including local community involvement (Ros-Tonen et al., 2008), that can help ensure both compliance with environmental laws and land tenure rights. In the longer term, reducing the Amazon's economic reliance on timber from native forests should provide the best approach (see Chapter 29), provided plantations are not leading to conversion of native forests.

27.4 Ecosystem degradation resulting from climate change & severe weather

Links between human actions, climate change, and climate extremes are now unequivocal or virtually certain (IPCC AR6 WG1). Such changes are also major drivers of ecosystem degradation in the Amazon (Chapter 22). Impacts can be direct and immediate, for example through droughts that cause widespread mortality of trees and aquatic life (e.g. Phillips *et al.* 2009; Lennox *et al.* 2019) or damaging floods (Marengo and Espinoza, 2016; Barichivich et al., 2018). Extreme climatic events alter the availability of keystone resources such as fruiting trees (Wright et al., 1999) and bring about major shifts in wildlife populations (Bodmer et al., 2018). Climate change can also act slowly, over long time periods, altering temperature and rainfall patterns, and increasing dry season length (Fu et al., 2013). These more gradual changes are associated with changes in tree species composition observed in long-term plot networks (Esquivel-Muelbert et al., 2019). Climate change and extremes can also act in concert with other disturbances to increase the likelihood of large scale megafires (e.g. Aragao et al. 2018, Withey et al. 2018) and forest dieback (Nobre et al., 2016) (See Chapters 22 and 24).

Addressing pervasive climatic drivers is challenging, requiring rapid global action to reach net zero CO_2 emissions as well as strong and sustained reductions in other greenhouse gas emissions (IPCC AR6). While reductions in the use of fossil fuels are fundamental, actions within the Amazon are also needed. First, the Amazon is in itself a critically important global carbon store and potential sink, and land-use change contributes the majority of emissions from Amazonian nations (Chapter 19). Local management to avoid deforestation and degradation and encourage forest restoration will therefore play a key role in mitigating global climate change (if conducted in concert with emission reductions elsewhere). Second, local management may be key to enable ecosystems to retain their innate resilience to climatic stress (e.g. França *et al.* 2020). Forest cover is in itself an important determinant of local climates, reducing temperatures and retaining water cycling (Chapters 7 and 29). Avoiding selective logging and buffering forest edges with regenerating forests could all help retain humid forest microclimates (Uhl and Kauffman, 1990), reducing the risk of forest fires. Trees in intact forests may also be more resilient to drought and fire stress, with lower levels of tree mortality (Berenguer et al., 2021). Local management that encourages free flowing rivers could also make aquatic systems more resilient to climate change and climatic extremes, as extreme weather exacerbates the impacts that large dams have on ecosystem functioning in downstream forests (Moser et al., 2019).

27.5 Infrastructure as a driver of change: Roads and Railways

Past experience suggests that, without dramatic changes in governance, increasing access to new regions via road building or paving will result in an inevitable increase in deforestation and environmental degradation (see Chapters 14 and 19). Given changes in governance are unlikely in the short term, and have not yet proven to be effective on smaller scales, maintaining the Amazon's integrity requires a very cautious approach to new road construction and improving existing transportation networks. This is especially important when implementing road building or improvement schemes across previously inaccessible regions, such as the IIRSA (the road planned in the 'Calha Norte' of the Brazilian Amazon) or the paving of highways such as BR319 between Manaus and Porto Velho. While all roads and railways have detrimental environmental consequences, some are worse than others. There needs to be greater distinction between roads and railways that are important for the local economy and people, and those which open up forest frontiers, encourage land grabbing and a wide range of illegal activities, or are motivated by geopolitical reasons or land speculation. While many unofficial roads are associated with deforestation, these are both symptoms of unplanned governance and land speculation as well as potential drivers of deforestation *per se*. Railways in the region are almost all tied to moving soy and/or mining products (Chapter 19). While railways may have less indirect impacts on surrounding forests than roads, they nonetheless act to fragment the region and hasten deforestation alongside the tracks (Chapter 19). Finally, large infrastructure developments must avoid protected areas and Indigenous territories.

27.6 Energy and mining as a driver of change

Instead of constructing major dams, alternative sources of renewable energy should be harnessed in the Amazon, including off-grid solar (Sánchez et al., 2015) and wind. Where dams are considered for regional power generation, the potential costs and benefits should be evaluated against alternative forms of energy generation, undertaking comprehensive impact assessments that consider the full social, environmental, and economic costs over the lifetime of the project, including decommissioning. Such assessments must include the indirect effects of large infrastructure projects, which can extend tens of kilometers into the surrounding forest (Chapter 19 and Chapter 20, Sonter *et al.* 2017). If implemented, the focus should be on smaller headwater hydropower stations along tertiary tributaries that minimise impacts on biodiversity, and should avoid the lower reaches of Amazonian rivers where impacts on socio-biodiversity are most pervasive. These smaller hydropower dams will still require full river catchment environmental analyses to understand and mitigate cumulative environmental impacts. They will require the removal of vegetation prior to flooding to minimize methane emissions, and there is a need to maintain dam-free river stretches containing representative sections of the original landscape (Lees et al., 2016). Approval of new dams should also be accompanied by trade-off analysis including realistic estimates of future energy production under different climate scenarios (Winemiller et al., 2016). Efforts to modernize older hydropower plants will result in considerable cost and time savings and lead to fewer ecological and social impacts – although decommissioning and a switch to alternative forms of renewable energy will likely provide the greatest environmental benefits.

27.7 Invasive species and diseases

Invasive species are a major driver of local and global extinctions across the world (Bellard et al. 2016), altering ecosystem processes and service provision, often in tandem with changes in habitat extent and quality driven directly by other human actions. These impacts are particularly prevalent in aquatic systems where invasive species can drive changes in the abundance of aquatic communities, especially fish, zooplankton, and macrophytes, which may lead to higher water turbidity and increased nitrogen and organic matter concentration (Gallardo et al. 2016). Although invasive species are widespread in the Amazon's aquatic ecosystems, our knowledge of their impacts and distribution is limited (Chapter 20). To date, most impacts have been demonstrated in riparian systems that experience higher propagule pressure of invasive non-native species (Doria et al., 2021). Many fish introductions (e.g. carp and tilapia) are deliberate and a perceived means of developing aquaculture and the economy. Such measures have recently received political endorsement by legal measures facilitating "naturalisation by decree" of such invasive fish species (Pelicice et al., 2014; Alves et al., 2018). This trend towards legalization of non-native species for aquaculture needs to be rolled back, and instead aquaculture producers should seek to develop new technologies for the production of native fish species; the Amazon has the most diverse reservoir of options globally.

Beyond introduced fish, aquatic ecosystems are also under threat from the invasive grass *Urochloa arrecta* (African Signalgrass), which competes with native macrophyte communities, leading to local extinctions which impoverish ecosystem services (Fares et al., 2020). Invasives like *Urochloa arrecta* are associated with altered environments and a breakdown in ecosystem integrity, especially increased canopy openness which facilitates invasion. As such, measures taken to restore closed-canopy riparian forests should help to restrict its spread. Enhanced biosecurity and treatment of ballast waters is needed to stop the spread of other aquatic species into the Amazon, such as the golden mussel *Limnoperna fortunei*, which has spread in adjacent basins (e.g., Paraná) and could represents a major threat to biodiversity as well as to economic activities (e.g., blocking pipelines of hydroelectric power plants and water-supplies) (Uliano-Silva et al., 2013). Monitoring can help ensure early detection, but needs to be accompanied by effective biosecurity protocols that prevent transport of invasive species into the Amazon. This requires coordinated management at various scales and the close cooperation of state and local governments.

Terrestrial systems are seemingly less threatened by invasive species in the Amazon, but there are examples, including the escape of the acacia (*Acacia mangium)* from large-scale commercial plantations into the surrounding Amazonian savannas (Aguiar et al. 2014). Silvicultural initiatives, including plantation forestry or forest restoration, should carry out a risk assessment on the invasion potential of the species being used, and contribute to controlling biological invasions should they occur. Disease surveillance efforts are needed to track diseases like yellow fever in primates (Ramos-Fernández and Wallace, 2008) and chytridiomycosis in amphibians which may be largely asymptomatic in the basin (Russell et al., 2019). Although these may not be major problems at present, they may represent serious threats for small, fragmented populations of Critically Endangered species in the future.

27.8 Human intrusions: War and unrest

The negative environmental impacts of within-country conflicts with non-state actors have been documented around the world (McNeely, 2003). Among drivers of deforestation, war and violent conflicts in tropical areas have affected forests and biodiversity of many countries in Latin America (McNeely, 2003; Fjeldså et al., 2005). The impacts of violence on tropical deforestation are mixed. In some cases, conflict increases rates of deforestation (McNeely, 2003; Hanson et al., 2009), due mainly to shifts in land tenure and changes of agricultural practices including the expansion of illicit crops (Negret et al., 2019). In other cases, by limiting access to the forest, armed groups have inadvertently reduced forest exploitation (Dávalos, 2001), prevented infrastructure and agriculture development (Reardon, 2018), and even facilitated recovery (McSweeney et al., 2014).

Post-conflict situations require careful management. In Colombia, after decades of unrest, the recent 2016 peace agreement expanded unsustainable development practices, resulting in an increase in deforestation in some frontier areas. A disproportionate increase in fires was the first signal indicating large-scale forest degradation (Armenteras et al., 2019) and transformation at the heart of key protected areas in the Colombian Amazon (Murillo-Sandoval et al., 2020). In Colombia, as in

Brazil, cattle ranching is used by land owners to claim ownership over newly cleared forests coupled with the lack of clarity of ownership of land property titles (Armenteras et al., 2019). Establishing legitimate government control and governance in former Amazonian conflict zones in Peru and Colombia is critical to ensure that deforestation rates do not increase during periods of transition. In Colombia this necessitates working with communities in Indigenous reserves and Afro-Colombian collective lands in order to set conservation objectives within a broader context of local development aspirations (Negret et al., 2019). Conservation and sustainable use also require the involvement of communities displaced by warfare, but this is being undermined by mass killings and murders of community leaders in Colombia (UN, 2021) and a rise in area of illicit crops (Murillo-Sandoval et al., 2020). Further, access to and distribution of land is still highly unequal in countries such as Brazil, Peru, and Colombia, and has been a major source of violent conflict for decades (Krause, 2020); curbing land speculation and land grabbing is essential to protect forests (Armenteras et al., 2019). Political, technical, and financial support for small farmers to ensure the transition from coca culture to other legal land use is needed and must be promoted. Some of the solutions lie outside of Amazonian countries. For example, deregulation and the legalization of drugs in the developed world would reduce income from organized crime and open up opportunities for sustainable development and conservation in regions affected by growing and trafficking (McSweeney et al., 2014).

27.9 Agricultural, aquacultural, and industrial waste; plastic waste; heavy metals and mercury

The Amazon needs a water quality monitoring network that extends across the many different river basins, providing a way of linking changes in quality with changes in biodiversity and ecosystem conditions. This is also key for human communities, given that rivers are the region's chief source of drinking water, but is untreated in many areas (Fenzl and Mathis, 2004). Although water is treated for consumption in Amazonian cities, wastewater treatment is often inexistent or ineffective and requires urgent investment (Chapter 20). Monitoring also needs to cover industrial and mining zones, such as Manaus (Amazonas) and Barcarena (Pará), respectively, where industrial waste tailing basins pose a major risk to human and ecosystem health (Medeiros et al., 2017).

Gold mining is the main source of mercury in river waters. It accumulates throughout the food chain up to humans, affecting especially human populations that rely heavily on fish consumption, leading to severe neurological and motor damage, even in those living several kilometers away from pollution sources (Chapter 21). These predominantly illegal activities need to be curbed though improved governance, enforcement, and protection of protected areas and Indigenous territories. Outside the Amazon, gold supply chains must be made transparent and held accountable for their sources, therefore cracking down on the increasing presence of illegal gold in international trade.

Urgent research is needed to understand the impact of pesticides on biodiversity and ecosystem services in both terrestrial and aquatic ecosystems (Chapter 19 and Chapter 20). Solutions involve more rigorous screening and licensing of chemicals, and better training for farmers in their use. This will reduce impacts arising from poor application techniques. These issues are especially pertinent in the south of the basin (Lathuillière et al., 2018). Plastic pollution is a growing issue, with microplastics found in several different fish species (Chapter 20). Country-specific actions (see Chapter 28) need to be supported by basin-wide regulation. For example, in Peru, public campaigns and single use plastic bans have been gaining momentum and such actions could be replicated across Amazonian countries.

27.10 Small dams created by agriculture and road infrastructure

In addition to river fragmentation driven by hydroelectric dams (see Section 2.5), watercourse fragmentation in the Amazon is also associated with inappropriate road crossings and culverts. Although these barriers are often small compared to hydroelectric dams, they have landscape-scale consequences for species assemblages (Schiesari et al., 2020) and are a direct threat to the highly diverse and unique fish assemblages found in the Amazon's streams (Leal et al., 2018). Even small reservoirs created upstream of roads are important drivers of instream habitat change (Leal et al., 2016). Inappropriate road crossings also isolate aquatic populations by interrupting dispersal pathways (Perkin and Gido, 2012), potentially hindering recolonization opportunities following stochastic and human-induced extinction events (Schumann et al., 2019; Wilkes et al., 2019), and shifting distributions due to climate change (Comte et al., 2014). Despite growing awareness of the benefits that can be gained from adapting the small but pervasive barriers created by road crossings (O'Shaughnessy et al., 2016), there is little incentive to do so; these crossings are considered as having low environmental impacts by the Brazilian Environmental Council (CONAMA 2006, resolution #369), discouraging restoration practices. However, even relatively minor changes to regulations could make an important difference. Many road crossings in the Amazon require frequent repairs, and replacing them with less-damaging structures (bridges) could have an attractive benefit-cost ratio.

27.11 Ecosystem degradation resulting from interactions between stressors

Many of the aforementioned stressors co-occur, and one set of stressors can amplify both the prevalence and impact of other stressors or create new problems. Here we highlight the importance of such interactions by focusing on forest fires, which are a key component in any large-scale Amazonian dieback (chapter 24), clearly highlight the complexity associated with interactive effects, and demonstrate that solutions need to target each of the drivers independently, requiring in turn multi-sectoral action. Global climate change is a key driver of fire prevalence, increasing both dry season lengths and temperatures (Brando et al., 2019). Maintaining the climate change mitigation potential of the Amazon is therefore itself dependent on reducing greenhouse gas emissions across the world. But while tackling climate change remains a global priority, this is likely to be a slow process with significant time lags even under best-case scenarios (Masson-Delmotte et al., 2121). Preventing forest fires in the coming decades will therefore require conservation and prevention measures that address their local causes (Barlow et al., 2020). Tackling deforestation is fundamental, as forest clearance is a major source of ignition, and augments the flammability of remaining forests by increasing edge density, raising regional temperatures, and reducing rainfall (Chapter 19).

But deforestation is not the only source of ignition in the landscape. Many forest fires start when fires in cattle pastures 'escape' (Barlow et al, 2020); this risk can be reduced by encouraging sustainable intensification of cattle ranching, which avoids pasture burning (Chapter 29). Traditional fire-dependent agriculture, such as farm-fallow systems using slash and burn (e.g. Padoch and Pinedo-Vasquez 2010) are more difficult to replace, as actions could have undesirable outcomes for sustainable land use, regional food security, and social justice. In these cases, conservation policies need to help farmers adapt existing farming practices, and must consider local perspectives (Carmenta et al., 2013). Fires could also be reduced by preventing illegal logging and any other actions provoking forest degradation, as the high offtake rates and lack of pre-cut planning or follow-up management make illegally logged forests especially vulnerable to fire, due to changes in the microclimate (Uhl and Kauffman, 1990). Finally, forest fires can be reduced by near-real-time monitoring and forecasting of drought intensity and fire risk, especially if linked to responsive, resourced, and capable local fire brigades. Fire brigades are fundamental to effective park management in the Bolivian and Brazilian Amazon, but remain chronically under-resourced (Nóbrega Spínola et al., 2020).

27.12 Conclusions

A broad suite of conservation measures is urgently needed to prevent further habitat loss and ecosystem degradation across the Amazon. Here we briefly outline some key actions. First, the prevention of deforestation and degradation is vital in some of the most deforested regions, especially in the south and east of the basin where several species are Critically Endangered. Second, measures are urgently needed across the entire basin to allow the Amazon's ecosystems to continue to provide local, regional, and global benefits and avoid the risk of large-scale forest dieback (Chapter 24). The focus on retaining forests and preventing degradation must be complemented by actions to protect aquatic and non-forest ecosystems. This will require multi-sectoral changes in the planning of energy and mining and the use of agrochemicals. Achieving such wide-ranging conservation measures will require actions that go beyond the traditional remit of conservation biology; instead, it will require a new vision for the Amazon's people and nature (Chapter 25), renewed support for protected areas and Indigenous lands (Chapter 31), and investment in alternative economic strategies (Chapter 30). Conservation progress will also benefit from a step change in investment in science within the Amazon to evaluate species status and distributions, and integrate Indigenous and local knowledge in this process (Chapter 33). Many species, especially invertebrates, are yet to be described. Ongoing taxonomic revisions are uncovering a large shortfall in our current understanding of Amazonian diversity, with many widespread species complexes being split into multiple restricted range species with much smaller distributions. The more we look at the Amazon's biota, the more reasons we will find to conserve it.

27.13 References

Aguiar Jr, A., Barbosa, R. I., Barbosa, J. B., & Mourão Jr, M. (2014). Invasion of Acacia mangium in Amazonian savannas following planting for forestry. Plant Ecology & Diversity, 7(1-2), 359-369.

Alencar, A. A. C., Solórzano, L. A., and Nepstad, D. C. (2004). Modeling forest understory fires in an eastern Amazonian landscape. Ecol. Appl. 14, 139–149.

Alves, G. H. Z., Tófoli, R. M., Lima-Júnior, D. P., Hoeinghaus, D. J., and others (2018). New decree promotes fish invasion in Amazon and Pantanal. Biodivers. Conserv. 27, 2449–2450.

Aragão, L. E., Anderson, L. O., Fonseca, M. G., Rosan, T. M., Vedovato, L. B., Wagner, F. H., ... & Saatchi, S. (2018). 21st Century drought-related fires counteract the decline of Amazon deforestation carbon emissions. Nature communications, 9(1), 1-12.

Arias, M., Hinsley, A., Nogales-Ascarrunz, P., Negroes, N., Glikman, J. A., & Milner-Gulland, E. J. (2021). Prevalence and characteristics of illegal jaguar trade in north-western Bolivia. Conservation Science and Practice, e444.

Armenteras, D., Negret, P., Melgarejo, L. F., Lakes, T. M., Londoño, M. C., García, J., et al. (2019). Curb land grabbing to save the Amazon. Nat. Ecol. Evol. 3, 1497–1497. doi:10.1038/s41559-019-1020-1.

Barichivich, J., Gloor, E., Peylin, P., Brienen, R. J. W., Schöngart, J., Espinoza, J. C., et al. (2018). Recent intensification of Amazon flooding extremes driven by strengthened Walker circulation. Sci. Adv. 4, eaat8785.

Barlow, J., Berenguer, E., Carmenta, R., and França, F. (2020). Clarifying Amazonia's burning crisis. Glob. Chang. Biol. 26, 319–321. doi:10.1111/gcb.14872.

Barlow, J., Peres, C. A., Henriques, L. M. P., Stouffer, P. C., & Wunderle, J. M. (2006). The responses of understorey birds to forest fragmentation, logging and wildfires: an Amazonian synthesis. Biological conservation, 128(2), 182-192.

Bellard, C., Cassey, P., & Blackburn, T. M. (2016). Alien species as a driver of recent extinctions. Biology letters, 12(2), 20150623.

Berenguer, E., Ferreira, J., Gardner, T. A., Aragão, L. E. O. C., De Camargo, P. B., Cerri, C. E., et al. (2014). A large-scale field assessment of carbon stocks in human-modified tropical forests. Glob. Chang. Biol. 20, 3713–3726.

Berenguer, E., Lennox, G. D., Ferreira, J., Malhi, Y., Aragão, L. E. O. C., Barreto, J. R., et al. (2021). Tracking the impacts of El Niño drought and fire in human-modified Amazonian forests. Proc. Natl. Acad. Sci. 118, 2019377118. doi:10.1073/PNAS.2019377118.

Blundell, A. G., and Gullison, R. E. (2003). Poor regulatory capacity limits the ability of science to influence the management of mahogany. in Forest Policy and Economics (Elsevier), 395–405. doi:10.1016/S1389-9341(03)00038-8.

Bodmer, R., Mayor, P., Antunez, M., Chota, K., Fang, T., Puertas, P., et al. (2018). Major shifts in Amazon wildlife populations from recent intensification of floods and drought. Conserv. Biol. 32, 333–344. doi:10.1111/cobi.12993.

Bragagnolo, C., Gama, G. M., Vieira, F. A. S., Campos-Silva, J. V., Bernard, E., Malhado, A. C. M., et al. (2019). Hunting in Brazil: What are the options? Perspect. Ecol. Conserv. 17, 71–79.

Brancalion, P. H. S., de Almeida, D. R. A., Vidal, E., Molin, P. G., Sontag, V. E., Souza, S. E. X. F., et al. (2018). Fake legal logging in the Brazilian Amazon. Sci. Adv. 4, eaat1192.

Branch, T. A., Lobo, A. S., and Purcell, S. W. (2013). Opportunistic exploitation: An overlooked pathway to extinction. Trends Ecol. Evol. 28, 409–413. doi:10.1016/j.tree.2013.03.003.

Brando, P. M., Silvério, D., Maracahipes-Santos, L., Oliveira-Santos, C., Levick, S. R., Coe, M. T., et al. (2019). Prolonged tropical forest degradation due to compounding disturbances: Implications for CO 2 and H 2 O fluxes. Glob. Chang. Biol. 25, 2855–2868. doi:10.1111/gcb.14659.

Carmenta, R., Vermeylen, S., Parry, L., and Barlow, J. (2013). Shifting Cultivation and Fire Policy: Insights from the Brazilian Amazon. Hum. Ecol. 41, 603–614. doi:10.1007/s10745-013-9600-1.

Castello, L., McGrath, D. G., and Beck, P. S. A. (2011). Resource sustainability in small-scale fisheries in the Lower Amazon floodplains. Fish. Res. 110, 356–364.

Chaudhary, A., Burivalova, Z., Koh, L. P., and Hellweg, S. (2016). Impact of Forest Management on Species Richness: Global Meta-Analysis and Economic Trade-Offs. Sci. Rep. 6, 1–10. doi:10.1038/srep23954.

Comte, L., Murienne, J., and Grenouillet, G. (2014). Species traits and phylogenetic conservatism of climate-induced range shifts in stream fishes. Nat. Commun. 5, 1–9. doi:10.1038/ncomms6053.

CONAMA (2006). Resolução Conama No 369, de 28 de março de 2006. Brazil.

Cuneyt Koyuncu, and Rasim Yilmaz (2008). The Impact of Corruption on Deforestation: A Cross-Country Evidence. J. Dev. Areas 42, 213–222. doi:10.1353/jda.0.0010.

Dávalos, L. M. (2001). The San Lucas mountain range in Colombia: how much conservation is owed to the violence? Biodivers. Conserv. 10, 69–78. doi:10.1023/A:1016651011294.

Degen, B., Ward, S. E., Lemes, M. R., Navarro, C., Cavers, S., and Sebbenn, A. M. (2013). Verifying the geographic origin of mahogany (Swietenia macrophylla King) with DNA-fingerprints. Forensic Sci. Int. Genet. 7, 55–62. doi:10.1016/j.fsigen.2012.06.003.

do Nascimento, C. A. R., Czaban, R. E., and Alves, R. R. N. (2015). Trends in illegal trade of wild birds in Amazonas state, Brazil. Trop. Conserv. Sci. 8, 1098–1113.

Doria, C. R. da C., Agudelo, E., Akama, A., Barros, B., Bonfim, M., Carneiro, L., et al. (2021). The Silent Threat of Non-native Fish in the Amazon: ANNF Database and Review. Front. Ecol. Evol. 0, 316. doi:10.3389/FEVO.2021.646702.

El Bizri, H. R., Morcatty, T. Q., Lima, J. J. S., and Valsecchi, J. (2015). The thrill of the chase: uncovering illegal sport hunting in Brazil through YouTubeTM posts. Ecol. Soc. 20.

Esquivel-Muelbert, A., Baker, T. R., Dexter, K. G., Lewis, S. L., Brienen, R. J. W., Feldpausch, T. R., et al. (2019). Compositional response of Amazon forests to climate change. Glob. Chang. Biol. 25, 39–56. doi:10.1111/gcb.14413.

Fares, A. L. B., Calvão, L. B., Torres, N. R., Gurgel, E. S. C., and Michelan, T. S. (2020). Environmental factors affect macrophyte diversity on Amazonian aquatic ecosystems inserted in an anthropogenic landscape. Ecol. Indic. 113, 106231.

Fenzl, N., and Mathis, A. (2004). Pollution of natural water resources in Amazonia: Sources, risks and consequences. Issues local Glob. use water from Amaz. Montevideo, UNESCO, 57–76.

Figueiredo, E. O., D'Oliveira, M. V. N., Locks, C. J., and Papa, D. de A. (2016). Estimativa do Volume de Madeira em Pátios de Estocagem de Toras por meio de Câmeras RGB Instaladas em Aeronaves Remotamente Pilotadas (ARP). Bol. Pesqui. Número 9 - Embrapa d, 1–59.

Finer, M., Jenkins, C. N., Sky, M. A. B., and Pine, J. (2014). Logging concessions enable illegal logging crisis in the peruvian amazon. Sci. Rep. 4, 1–6. doi:10.1038/srep04719.

Fischer, R., Giessen, L., and Günter, S. (2020). Governance effects on deforestation in the tropics: A review of the evidence. Environ. Sci. Policy 105, 84–101. doi:10.1016/j.envsci.2019.12.007.

Fjeldså, J., Álvarez, M. D., Lazcano, J. M., and León, B. (2005). Illicit Crops and Armed Conflict as Constraints on Biodiversity Conservation in the Andes Region. AMBIO A J. Hum. Environ. 34, 205–211. doi:10.1579/0044-7447-34.3.205.

França, F. M., Frazão, F. S., Korasaki, V., Louzada, J., & Barlow, J. (2017). Identifying thresholds of logging intensity on dung beetle communities to improve the sustainable management of Amazonian tropical forests. Biological Conservation, 216, 115-122.

França, F. M., Benkwitt, C. E., Peralta, G., Robinson, J. P. W., Graham, N. A. J., Tylianakis, J. M., et al. (2020). Climatic and local stressor interactions threaten tropical forests and coral reefs. Philos. Trans. R. Soc. B Biol. Sci. 375. doi:10.1098/rstb.2019.0116.

Fu, R., Yin, L., Li, W., Arias, P. A., Dickinson, R. E., Huang, L., et al. (2013). Increased dry-season length over southern Amazonia in recent decades and its implication for future climate projection. Proc. Natl. Acad. Sci. 110, 18110–18115. doi:10.1073/pnas.1302584110.

Garcia-Frapolli, E., Ayala-Orozco, B., Bonilla-Moheno, M., Espadas-Manrique, C., and Ramos-Fernández, G. (2007). Biodiversity conservation, traditional agriculture and ecotourism: Land cover/land use change projections for a natural protected area in the northeastern Yucatan Peninsula, Mexico. Landsc. Urban Plan. 83, 137–153.

Gallardo, B., Clavero, M., Sánchez, M. I., & Vilà, M. (2016). Global ecological impacts of invasive species in aquatic ecosystems. Global change biology, 22(1), 151-163.

Hanson, T., Brooks, T. M., Da Fonseca, G. A. B., Hoffmann, M., Lamoreux, J. F., Machlis, G., et al. (2009). Warfare in Biodiversity Hotspots. Conserv. Biol. 23, 578–587. doi:10.1111/j.1523-1739.2009.01166.x.

Ibarra, J. T., Barreau, A., Campo, C. Del, Camacho, C. I., Martin, G. J., and McCandless, S. R. (2011). When formal and market-based conservation mechanisms disrupt food sovereignty: impacts of community conservation and payments for environmental services on an indigenous community of Oaxaca, Mexico. Int. For. Rev. 13, 318–337.

ITTO/IUCN (2009). Guidelines for the conservation and sustainable use of biodiversity in tropical timber production forests. ITTO Policy Development Series No 17 ITTO/IUCN.

ITTO (2015). Guidelines for the sustainable management of natural tropical forests. ITTO Policy Development Series. , ed. I. I. T. T. Organization Yokohama, Japan. Available at: www.itto.int [Accessed April 23, 2021].

Krause, T. (2020). Reducing deforestation in Colombia while building peace and pursuing business as usual extractivism? J. Polit. Ecol. 27, 401–418.

Lathuillière, M. J., Coe, M. T., Castanho, A., Graesser, J., and

Johnson, M. S. (2018). Evaluating water use for agricultural intensification in Southern Amazonia using the Water Footprint Sustainability Assessment. Water 10, 349.

Leal, C. G., Barlow, J., Gardner, T. A., Hughes, R. M., Leitão, R. P., Nally, R. Mac, et al. (2018). Is environmental legislation conserving tropical stream faunas? A large-scale assessment of local, riparian and catchment-scale influences on Amazonian fish. J. Appl. Ecol. 55, 1312–1326. doi:10.1111/1365-2664.13028.

Leal, C. G., Pompeu, P. S., Gardner, T. A., Leitão, R. P., Hughes, R. M., Kaufmann, P. R., et al. (2016). Multi-scale assessment of human-induced changes to Amazonian instream habitats. Landsc. Ecol. 31, 1725–1745.

Lees, A. C., Peres, C. A., Fearnside, P. M., Schneider, M., and Zuanon, J. A. S. (2016). Hydropower and the future of Amazonian biodiversity. Biodivers. Conserv. 25, 451–466.

Lennox, R. J., Crook, D. A., Moyle, P. B., Struthers, D. P., and Cooke, S. J. (2019). Toward a better understanding of freshwater fish responses to an increasingly drought-stricken world. Rev. Fish Biol. Fish. 29, 71–92. doi:10.1007/s11160-018-09545-9.

Machado, R. B., Silveira, L. F., da Silva, M. I. S. G., Ubaid, F. K., Medolago, C. A., Francisco, M. R., et al. (2019). Reintroduction of songbirds from captivity: the case of the Great-billed Seed-finch (Sporophila maximiliani) in Brazil. Biodivers. Conserv., 1–24.

Marengo, J. A., and Espinoza, J. C. (2016). Extreme seasonal droughts and floods in Amazonia: Causes, trends and impacts. Int. J. Climatol. 36, 1033–1050. doi:10.1002/joc.4420.

Marshall, H., Collar, N. J., Lees, A. C., Moss, A., Yuda, P., and Marsden, S. J. (2020). Characterizing bird-keeping user-groups on Java reveals distinct behaviours, profiles and potential for change. People Nat. 2, 877–888.

Mason, D. (1996). Responses of Venezuelan understory birds to selective logging, enrichment strips, and vine cutting. Biotropica, 296-309.

Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, S., Berger, N., et al. (2121). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Available at: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf [Accessed November 8, 2021].

McNeely, J. A. (2003). Conserving forest biodiversity in times of violent conflict. Oryx 37, 142–152. doi:10.1017/S0030605303000334.

McSweeney, K., Nielsen, E. A., Taylor, M. J., Wrathall, D. J., Pearson, Z., Wang, O., et al. (2014). Drug Policy as Conservation Policy: Narco-Deforestation. Science (80-.). 343, 489–490. doi:10.1126/science.1244082.

Medeiros, A. C., Faial, K. R. F., Faial, K. do C. F., da Silva Lopes, I. D., de Oliveira Lima, M., Guimarães, R. M., et al. (2017). Quality index of the surface water of Amazonian rivers in industrial areas in Pará, Brazil. Mar. Pollut. Bull. 123, 156–164.

Morcatty, T. Q., Bausch Macedo, J. C., Nekaris, K. A. I., Ni, Q., Durigan, C. C., Svensson, M. S., & Nijman, V. (2020). Illegal trade in wild cats and its link to Chinese-led development in Central and South America. Conservation Biology, 34(6), 1525-1535.

Moser, P., Simon, M. F., Medeiros, M. B., Gontijo, A. B., and Costa, F. R. C. (2019). Interaction between extreme weather events and mega-dams increases tree mortality and alters functional status of Amazonian forests. J. Appl. Ecol. 56, 2641–2651. doi:10.1111/1365-2664.13498.

Murillo-Sandoval, P. J., Dexter, K. Van, Hoek, J. Van Den, Wrathall, D., and Kennedy, R. (2020). The end of gunpoint conservation: forest disturbance after the Colombian peace agreement. Environ. Res. Lett. 15, 34033. doi:10.1088/1748-9326/ab6ae3.

Myers, R. A., and Mertz, G. (1998). The limits of exploitation: a precautionary approach. Ecol. Appl. 8, S165--S169.

Negret, P. J., Sonter, L., Watson, J. E. M., Possingham, H. P., Jones, K. R., Suarez, C., et al. (2019). Emerging evidence that armed conflict and coca cultivation influence deforestation patterns. Biol. Conserv. 239, 108176.

Nobre, C. A., Sampaio, G., Borma, L. S., Castilla-Rubio, J. C., Silva, J. S., and Cardoso, M. (2016). Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. Proc. Natl. Acad. Sci. 113, 10759–10768. doi:10.1073/pnas.1605516113.

Nóbrega Spínola, J., Soares da Silva, M. J., Assis da Silva, J. R., Barlow, J., and Ferreira, J. (2020). A shared perspective on managing Amazonian sustainable-use reserves in an era of megafires. J. Appl. Ecol. 57, 2132–2138. doi:10.1111/1365-2664.13690.

O'Shaughnessy, E., Landi, M., Januchowski-Hartley, S. R., and Diebel, M. (2016). Conservation leverage: Ecological design culverts also return fiscal benefits. Fisheries 41, 750–757.

Padoch, C., and Pinedo-Vasquez, M. (2010). Saving Slash-and-Burn to Save Biodiversity. Biotropica 42, 550–552. doi:10.1111/j.1744-7429.2010.00681.x.

Parry, L., Barlow, J., and Pereira, H. (2014). Wildlife harvest and consumption in Amazonia's urbanized wilderness. Conserv. Lett. 7, 565–574.

Parry, L., and Peres, C. A. (2015). Evaluating the use of local ecological knowledge to monitor hunted tropical-forest wildlife over large spatial scales. 20. doi:10.5751/ES-07601-200315.

Pelicice, F. M., Vitule, J. R. S., Lima Junior, D. P., Orsi, M. L., and Agostinho, A. A. (2014). A serious new threat to Brazilian freshwater ecosystems: the naturalization of nonnative fish by decree. Conserv. Lett. 7, 55–60.

Perkin, J. S., and Gido, K. B. (2012). Fragmentation alters stream fish community structure in dendritic ecological networks. Ecol. Appl. 22, 2176–2187. doi:10.1890/12-0318.1.

Phelps, J., Webb, E. L., Bickford, D., Nijman, V., and Sodhi, N. S. (2010). Conservation. Boosting CITES. Science 330, 1752–1753. doi:10.1126/SCIENCE.1195558.

Phillips, O. L., Aragão, L. E. O. C., Lewis, S. L., Fisher, J. B., Lloyd, J., López-González, G., et al. (2009). Drought sensitivity of the Amazon rainforest. Science (80-.). 323, 1344–1347.

Piponiot, C., Rödig, E., Putz, F. E., Rutishauser, E., Sist, P., Ascarrunz, N., et al. (2019). Can timber provision from Amazonian production forests be sustainable? Environ. Res. Lett. 14, 064014. doi:10.1088/1748-9326/ab195e.

Ramos-Fernández, G., and Wallace, R. B. (2008). Spider monkey conservation in the twenty-first century: recognizing risks and opportunities. Spider monkeys Behav. Ecol. Evol. genus Ateles, 351–376.

Reardon, S. (2018). FARC and the forest: Peace is destroying Colombia's jungle - and opening it to science. Nature 558, 169–170. doi:10.1038/d41586-018-05397-2.

Richardson, V. A., and Peres, C. A. (2016). Temporal Decay in Timber Species Composition and Value in Amazonian Logging Concessions. PLoS One 11, e0159035. doi:10.1371/journal.pone.0159035.

Ros-Tonen, M. A. F., Van Andel, T., Morsello, C., Otsuki, K., Rosendo, S., and Scholz, I. (2008). Forest-related partnerships in Brazilian Amazonia: there is more to sustainable forest management than reduced impact logging. For. Ecol. Manage. 256, 1482–1497.

Russell, I. D., Larson, J. G., von May, R., Holmes, I. A., James, T. Y., and Davis Rabosky, A. R. (2019). Widespread chytrid infection across frogs in the Peruvian Amazon suggests critical role for low elevation in pathogen spread and persistence. PLoS One 14, e0222718.

Sánchez, A. S., Torres, E. A., and Kalid, R. A. (2015). Renewable energy generation for the rural electrification of isolated communities in the Amazon Region. Renew. Sustain. Energy Rev. 49, 278–290. doi:10.1016/j.rser.2015.04.075.

Santos de Lima, L., Merry, F., Soares-Filho, B., Oliveira Rodrigues, H., dos Santos Damaceno, C., and Bauch, M. A. (2018). Illegal logging as a disincentive to the establishment of a sustainable forest sector in the Amazon. PLoS One 13, e0207855. doi:10.1371/journal.pone.0207855.

Schiesari, L., Ilha, P. R., Negri, D. D. B., Prado, P. I., and Grillitsch, B. (2020). Ponds, puddles, floodplains and dams in the Upper Xingu Basin: could we be witnessing the 'lentification'of deforested Amazonia? Perspect. Ecol. Conserv. doi:10.1016/j.pecon.2020.05.001.

Schumann, D. A., Haag, J. M., Ellensohn, P. C., Redmond, J. D., and Graeb, K. N. B. (2019). Restricted movement of prairie fishes in fragmented riverscapes risks ecosystem structure being ratcheted downstream. Aquat. Conserv. Mar. Freshw. Ecosyst. 29, 235–244. doi:10.1002/aqc.2996.

Sist, P., and Ferreira, F. N. (2007). Sustainability of reduced-impact logging in the Eastern Amazon. For. Ecol. Manage. 243, 199–209.

Sist, P., Piponiot, C., Kanashiro, M., Pena-Claros, M., Putz, F. E., Schulze, M., et al. (2021). Sustainability of Brazilian forest concessions. For. Ecol. Manage. 496, 119440. doi:10.1016/J.FORECO.2021.119440.

Sonter, L. J., Herrera, D., Barrett, D. J., Galford, G. L., Moran, C. J., and Soares-Filho, B. S. (2017). Mining drives extensive deforestation in the Brazilian Amazon. Nat. Commun. 8, 1013. doi:10.1038/s41467-017-00557-w.

Ubaid, F. K., Silveira, L. F., Medolago, C. A. B., Costa, T. V. V, Francisco, M. R., Barbosa, K. V. C., et al. (2018). Taxonomy, natural history, and conservation of the Great-billed Seed-Finch Sporophila maximiliani (Cabanis, 1851)(Thraupidae, Sporophilinae). Zootaxa 4442, 551–571.

Uhl, C., and Kauffman, J. B. (1990). Deforestation, fire susceptibility, and potential tree responses to fire in the eastern Amazon. Ecology 71, 437–449. doi:10.2307/1940299.

Uliano-Silva, M., Fernandes, F., de Holanda, I. B. B., and Rebelo, M. F. (2013). Invasive species as a threat to biodiversity: the golden mussel Limnoperna fortunei approaching the Amazon River basin. Explor. Themes Aquat. Toxicol. Res. Signpost, India.

Vidal, E., West, T. A. P., Lentini, M., Souza, S. E. X. ., Klauberg, C., and Waldhoff, P. (2020). "Sustainable forest management (SFM) of tropical moist forests: the case of the Brazilian Amazon," in Achieving Sustainable Management of Tropical Forests., 1–31. doi:10.19103/AS.2020.0074.42.

West, T. A. P., Vidal, E., and Putz, F. E. (2014). Forest biomass recovery after conventional and reduced-impact logging in Amazonian Brazil. For. Ecol. Manage. 314, 59–63. doi:10.1016/j.foreco.2013.11.022.

Wilkes, M. A., Webb, J. A., Pompeu, P. S., Silva, L. G. M., Vowles, A. S., Baker, C. F., et al. (2019). Not just a migration problem: Metapopulations, habitat shifts, and gene flow are also important for fishway science and management. in River Research and Applications (John Wiley and Sons Ltd), 1688–1696. doi:10.1002/rra.3320.

Wilkie, D. S., and Carpenter, J. F. (1999). Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. Biodivers. Conserv. 8, 927–955.

Winemiller, K. O., McIntyre, P. B., Castello, L., Fluet-Chouinard, E., Giarrizzo, T., Nam, S., et al. (2016). Balancing hydropower and biodiversity in the Amazon, Congo, and Mekong. Science (80-.). 351, 128–129.

Winter, S. C., and May, P. J. (2001). Motivation for compliance with environmental regulations. J. Policy Anal. Manag. J. Assoc. Public Policy Anal. Manag. 20, 675–698.

Wright, S. J., Carrasco, C., Calderon, O., and Paton, S. (1999). The El Nino Southern Oscillation, Variable Fruit Production, and Famine in a Tropical Forest. Ecology 80, 1632. doi:10.2307/176552.

Zu Ermgassen, E. K. H. J., Godar, J., Lathuillière, M. J., Löfgren, P., Gardner, T., Vasconcelos, A., et al. (2020). The origin, supply chain, and deforestation risk of Brazil's beef exports. Proc. Natl. Acad. Sci. U. S. A. 117, 31770–31779. doi:10.1073/pnas.2003270117.

Amazon Assessment Report 2021

Chapter 28

Restoration options for the Amazon

Barcarena, Pará: bacia de rejeitos da Alunorte, controlada pela Norsk Hydro (Foto Pedrosa Neto/Amazônia Real)

INDEX

GRAPHICAL ABSTRACT ... 2
KEY MESSAGES ... 3
28.1 INTRODUCTION ... 4
28.2 DEFINITIONS AND AIMS OF RESTORATION ... 4
28.2.1 Ecosystem restoration ... 4
28.2.2 Functional restoration ... 5
28.2.3 Rewilding ... 5
28.2.4 Remediation ... 5
28.3 TERRESTRIAL RESTORATION TECHNIQUES AND OPTIONS ... 6
28.3.1 Restoration after complete removal of soil ... 6
28.3.2 Restoration of vegetation on deforested land ... 8
28.3.3 Restoration of degraded forests ... 10
28.3.4 Restoration of sustainable economic activities in deforested lands ... 12
28.3.4.1 Sustainable intensification of pastures ... 13
28.3.4.2 Agroforestry ... 14
28.3.4.3 Farm fallow systems ... 14
28.4 AQUATIC RESTORATION TECHNIQUES AND OPTIONS ... 15
28.4.1 Restoration after pollution ... 15
28.4.2 Dam removal and restoring natural flow cycles and connectivity ... 16
28.4.2.1 Restoring fisheries and curbing overfishing ... 17
28.4.2.2 Restoring floodplains ... 19
28.5 INDICATORS OF SUCCESS ... 21
28.6 CONCLUSION ... 21
28.7 REFERENCES ... 22

Graphical Abstract

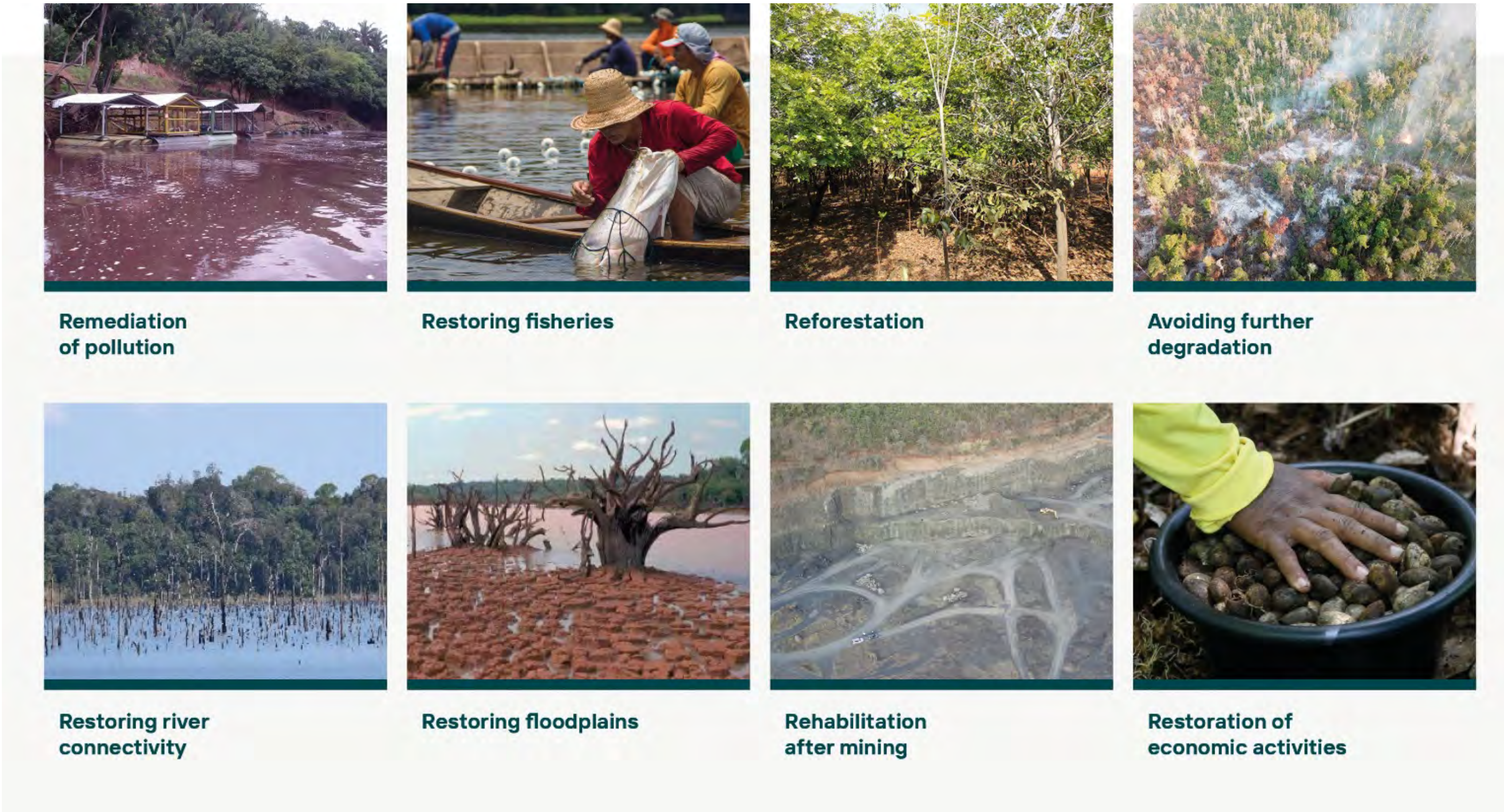


Figure 28.A Restorations option for the Amazon. Photographers: Nélio Saldanha, Amanda Lelis, Reinaldo Bozelli, Lilian Blanc, Alexander Lees, Jochen Schöngart, Nádia Pontes (from top-left to bottom-right).

Restoration Options for the Amazon

Jos Barlow[a*], *Plinio Sist*[bc*], *Rafael Almeida*[d], *Caroline C. Arantes*[e], *Erika Berenguer*[a,f], *Patrick Caron*[c], *Francisco Cuesta*[g], *Carolina R. C. Doria*[h], *Joice Ferreira*[i], *Alexander Flecker*[c], *Sebastian Heilpern*[j], *Michelle Kalamandeen*[k], *Alexander C. Lees*[l], *Marielos Peña-Claros*[m], *Camille Piponiot*[n], *Paulo Santos Pompeu*[o], *Carlos Souza*[p], *Judson F. Valentim*[q]

Key Messages

- Restoration encompasses a broad suite of objectives related to the practice of recovering biodiversity and ecosystem functions and services, such as water quality, carbon sequestration, and peoples' livelihoods. It spans the aquatic and terrestrial realms and goes beyond natural ecosystems to include the recovery of socially-just and sustainable economic activities on deforested lands.
- Within terrestrial systems, site-specific restoration options include speeding up recovery after mining, reforesting deforested land, facilitating the recovery of degraded primary forests, and restoring sustainable economic activities on deforested lands via sustainable intensification, agroforestry, or improving farm-fallow systems.
- Restoring aquatic systems requires applying techniques to remediate polluted aquatic and terrestrial habitats, including those affected by mining, petroleum, and plastic; developing and enforcing rules to reinstate natural flow regimes; removing barriers that fragment rivers and disrupt connectivity; and implementing collaborative partnerships to recover fisheries and floodplain habitats.
- The high cost and complexity of many restoration options mean they should only be used as a last resort. For vast areas of the Amazon, the primary aim should be to avoid the need for future restoration by conserving intact forests and waterbodies.

[a] Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK, jos.barlow@lancaster.ac.uk
[b] Agricultural Research Centre for International Development – France. CIRAD, sist@cirad.fr.
[c] Université de Montpellier, UR Forests & Societies, Montpellier 34398, France.
[d] Department of Ecology and Evolutionary Biology, Cornell University, E145 Corson Hall, Ithaca NY 14853, USA
[e] Center for Global Change and Earth Observations, Michigan State University, 218 Manly Miles Building, 1405 S. Harrison Road, East Lansing MI 48823, USA
[f] Environmental Change Institute, Oxford University Centre for the Environment, University of Oxford, South Parks Road, Oxford OX1 3QY, UK
[g] Grupo de Investigación en Biodiversidad, Medio Ambiente y Salud (BIOMAS), Universidad de Las Américas (UDLA), De Los Colimes esq, Quito 170513, Ecuador
[h] Laboratório de Ictiologia e Pesca, Departamento de Ciências Biológicas, Universidade Federal de Rondônia (UNIR), Av. Pres. Dutra 2965, Olaria, Porto Velho RO 76801-058, Brazil
[i] Embrapa Amazonia Oriental, Trav. Dr. Enéas Pinheiro, s/n°, Bairro Marco, Belém PA 66095-903, Brazil
[j] Department of Natural Resources, Cornell University, 226 Mann Drive, Ithaca NY 14853, USA
[k] School of Geography, University of Leeds, Leeds LS2 9JT, UK
[l] Department of Natural Sciences, Manchester Metropolitan University, All Saints Building, Manchester M15 6BH, UK
[m] Department of Environmental Sciences, Wageningen University & Research, PO Box 47, 6700AA Wageningen, The Netherlands
[n] Smithsonian Conservation Biology Institute & Smithsonian Tropical Research Institute, 3001 Connecticut Avenue NW, Washington DC 20008, USA
[o] Departamento de Ecologia e Conservação, Instituto de Ciências Naturais, Universidade Federal de Lavras, Aquenta Sol, Lavras MG 37200-900, Brazil
[p] Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), Trav. Dom Romualdo de Seixas 1698, Edifício Zion Business 11th Floor, Bairro Umarizal, Belém PA 66055-200, Brazil
[q] Agroforestry Research Center of Acre, Embrapa Acre, Rodovia BR-364, Km 14 (Rio Branco/Porto Velho), Rio Branco AC 69900-970, Brazil

Abstract

This chapter examines site-specific opportunities and approaches for restoring terrestrial and aquatic systems, focusing on local actions and their immediate benefits. Landscape, catchment, and biome-wide considerations are addressed in Chapter 29. Conservation approaches are addressed in Chapter 27

Keywords: remediation, rehabilitation, rewilding, succession, fishing.

28.1 Introduction

Human-driven changes across Amazonian landscapes have affected biodiversity and associated ecological processes (Chapters 19 and 20); this, in turn, has direct and indirect impacts on human well-being (Chapter 21). Although much of the focus in the Amazon should be on preventing further ecosystem loss and degradation (see Chapter 27), there is growing awareness of the importance of restorative actions aimed at reversing these processes. Restorative actions are supported internationally by initiatives such as the Bonn Challenge, New York Declaration on Forests, and UN Decade of Ecosystem Restoration. At the same time, there is increasing recognition of the role that nature-based solutions can play in addressing societal challenges (Seddon *et al.*, 2019); these encompass protection, restoration, or sustainably managed aquatic and terrestrial ecosystems whether natural, man-made, or a combination of both (Cohen-Shacham *et al.*, 2016). Restoration is also about local livelihoods; small-scale agriculture and fisheries are vital livelihoods for millions of people inhabiting the region. There is increasing evidence of the benefits restoration can provide to people, including restoring sustainable and socially-just economic activities, that must be considered when designing successful restoration approaches. This chapter focusses on site-specific approaches for restoration in terrestrial and aquatic systems. Landscape, catchment, multiple stakeholders, and whole-biome considerations are assessed in Chapter 29. Before examining the role of restoration in different Amazonian contexts, we examine the aims and definitions across the aquatic and terrestrial realms, both internationally and within Amazonian countries (Fagan *et al.*, 2020; Mansourian, 2018).

28.2 Definitions and aims of restoration

We use restoration as an overarching term that encompasses the broad suite of objectives that can be met by improving biodiversity protection and conservation, ecosystem functions and services such as water quality, local or global climate change mitigation measures, or the livelihoods of regional stakeholders (Chazdon and Brancalion, 2019). While ecosystem and functional restoration, rewilding, rehabilitation, and remediation can be seen as different and independent actions, they can also be considered as part of a continuum which includes a range of activities and interventions that can improve environmental conditions and reverse ecosystem degradation and landscape fragmentation (Gann *et al.*, 2019). Crucially, our use of restoration also includes the recovery of sustainable and socially-just economic activities on deforested lands. Finally, restoration also encompasses preventing further degradation, recognizing that effective actions will require avoiding further environmental harm as well as encouraging recovery. As such, throughout chapters 28 and 29, the term restoration will be used to include the following approaches, many of which are non-exclusive and/or mutually beneficial.

28.2.1 Ecosystem restoration

Historically, ecosystem restoration means the recovery of ecosystems to a reference site (e.g. primary or pristine forests) (in Palmer *et al.*, 2014). Full recovery is defined as the state or condition whereby, following restoration, all key ecosystem attributes closely resemble those of the reference model, including absence of threats, species composition, community structure, physical conditions, ecosystem function, and external exchanges

(Gann *et al.*, 2019). Within the Amazon, full recovery may be a forest with equivalent richness and species composition to an old growth forest, or a river with the full complement of aquatic species. Ecosystem recovery is most likely in areas where the scale and intensity of disturbance has been minimal (e.g. recovery of faunal communities after overfishing or hunting).

28.2.2 Functional restoration

Targeting recovery to pristine conditions is not necessarily the main objective of every restoration program. Many restoration programs developed within the framework of the Bonn challenge target the restoration of ecological and ecosystem functions at the landscape level, while enhancing human well-being (Stanturf *et al.*, 2015). This "functional restoration" can also be called rehabilitation, and can facilitate the inclusion of socio-economic and human dimensions of restoration actions (Gann *et al.*, 2019). Forest landscape restoration (FLR) includes actions referring to both ecological restoration and rehabilitation (See Stanturf *et al.*, 2015, for definition of FLR). Nowadays, the human and social dimension of restoration actions can no longer be overlooked or ignored because the long-term success of restoration programs depends on it (Gann *et al.*, 2019).

28.2.3 Rewilding

The concept of rewilding has gone beyond its original association with large predators and lost Pleistocene fauna (e.g. Soulé and Noss, 1998) to deliver "*the reorganisation of biota and ecosystem processes to set an identified social–ecological system on a preferred trajectory, leading to the self-sustaining provision of ecosystem services with minimal ongoing management*" (Pettorelli *et al.*, 2018). Unlike functional or ecosystem restoration, rewilding does not aim for a specific target (e.g. biomass levels or species composition), but instead aims for a wilder system where a full suite of ecosystem processes are played out across trophic levels. While rewilding can be very different from target-driven restoration in many temperate contexts, within the Amazon the differences are less obvious; the most prevalent forms of restoration, such as the passive succession of secondary forest, could also be considered a form of rewilding under the definition of Pettorelli *et al.* (2018). Furthermore, with appropriate management interventions (including those related to hunting and fishing, see Chapter 27), most Amazonian secondary forests and rivers will eventually provide habitat for the largest vertebrates and apex predators.

28.2.4 Remediation

Remediation involves stopping or reducing pollution that is threatening the health of people, wildlife, or ecosystems, in contrast with restoration which refers to actions that directly improve environmental services or other ecological properties (Efroymson *et al.*, 2004). Remediation, therefore, generally occurs before restoration, and can help create the basic conditions for implementing restoration. Remediation actions vary, and can involve leaving contamination in place, allowing natural attenuation, removing or isolating contaminants, and improving ecological value through onsite or offsite restoration that does not involve removing contaminants (Efroymson *et al.* 2004). Within the Amazon, an example includes the remediation of localized soil contamination combined with natural attenuation and the planting of trees (Efroymson *et al.* 2004).

28.2.5 Additional definitions

Beyond defining what is restoration, there are some additional definitions that are useful to clarify. Ecosystem restoration strategies can be either (human) assisted or passive (i.e natural regeneration). We specify which approach is required where this is important to the outcome, but recognize that there is often a continuum of actions, and even passive actions require some active decision making and management interventions (e.g. fire control, fencing, etc). It is also important to clarify terminology about different disturbance classes (see Chapter 19). We use "primary forests" to describe forests that have never knowingly been clearfelled, accepting that there is a lack of certainty about pre-Colombian history (see Chapter 8), and that some forests will be considered "primary" by remote sensing if they pre-date the widespread availability of Landsat imagery in 1984. While deforestation – the loss of forest cover and conversion to an alternative land-use – is easily defined, there is less agreement over forest degradation (Sasaki and Putz, 2009) and secondary forests (Putz and Redford, 2010). We follow the definition of Parrota *et al.* (2012) that forests are considered degraded if disturbance has led to "*changes in forest condition that result in the reduction of the capacity of a forest to provide goods and services*" (Thompson *et al.*, 2012). We define secondary forests as those regrowing after clear-felling and, normally, after an alternative land-use such as pasture or cropland (Putz and Redford, 2010). We consider that forest degradation can affect both primary and secondary forests, through processes such as selective logging, extreme weather, fires, and edge or isolation effects (Brando *et al.*, 2014; Negrón-Juárez *et al.*, 2010). The degree of degradation depends on the cause (fire, logging, fragmentation), the intensity of degradation (e.g. low versus high logging intensity) and the frequency (repetitive logging, repetitive fire) (Chapter 19) (Barlow and Peres, 2008; Bourgoin *et al.*, 2020; Matricardi *et al.*, 2020). Finally, for terrestrial restoration, we retain a strong focus on forests, which are by far the most dominant ecosystem across the basin. However, other important ecosystems, including native grasslands, savannas, and paramos, also suffer from degradation and conversion, and the restoration of these ecosystems is also key to maintaining biodiversity, ecological functioning, and the provision of ecosystem services (Veldman, 2016).

28.3 Terrestrial restoration techniques and options

This section provides a technical and evidence-based review of the site-specific restoration options required in terrestrial systems following disturbances caused by the drivers addressed in Chapters 19 and 20. Each section briefly outlines when restoration is most relevant, the technical options that exist and their efficacy, the ecological and environmental benefits (and limits), and the social and economic viability (including benefits and challenges).

28.3.1 Restoration after complete removal of soil

The extraction of minerals and fossil fuels are increasingly significant drivers of tropical deforestation and degradation, biodiversity loss, and greenhouse gas emissions in the Amazon (Fearnside, 2005). Around 21% of the region is under potential hydrocarbon (327 oil and gas blocks covering ~108 million ha) and mineral (160 million ha) exploration (RAISG, 2020). Most mineral mining activities are centered around the Guiana Shield and North-Central regions of Brazil, while fossil fuel extraction occurs primarily in the western Amazon (mostly Peru, Ecuador, and Bolivia [RAISG 2020], Chapter 19). The magnitude of these industries varies from small scale artisanal activities (minerals) to large scale (mineral and hydrocarbon), with the latter often run by larger corporations on privately leased lands (Asner *et al.*, 2013; Kalamandeen *et al.*, 2018; Lobo *et al.*, 2016; Sonter *et al.*, 2017), overlapping ~20% of Indigenous territories (Herrera-R *et al.*, 2020). The process for these activities ensures that forests are cleared, and the topsoil stripped away to establish mines, wells, pipelines, and infrastructure associated with roads and housing (Laurance *et al.*, 2009; McCracken and Forstner, 2014; Sonter *et al.*, 2017).

The extent of soil damage and chemical contamination associated with both mineral and hydrocarbon excavation sets it apart from other traditional deforestation drivers such as agriculture and pasture-based cattle ranching (Santos-Francés *et al.*, 2011; Wantzen and Mol, 2013). Mineral and hydrocarbon extraction alter soil structure, disrupt nutrient cycling (nitrogen and phosphorus), and severely inhibit forest recovery by destroying the soil seed bank and soil biota (Barrios *et al.*, 2012; Kalamandeen *et al.*, 2020; Lamb *et al.*, 2005). It can also disrupt important aboveground ecosystem services such as pollination, seed dispersal, and pest control. Additional ancillary effects such as soil erosion and surface and groundwater pollution through mercury contamination and/or acid mine drainage can be detected hundreds of kilometers away from mine-leased sites (Diringer *et al.*, 2015; Sonter *et al.*, 2017). For such severely degraded and polluted systems, distance to primary forest seed banks appear to have limited impact on recovery (Kalamandeen *et al.*, 2020).

The level of degradation from hydrocarbon extraction means that full recovery is highly unlikely, and recovery rates are low or can be stalled completely (Kalamandeen *et al.*, 2020). As a result, focusing on reviving functional (primary production, energy flows, and nutrient cycles) and ecological processes (e.g. species composition, dispersal mechanisms, distinct evolutionary lineages) through active restoration becomes crucial (Chazdon *et al.*, 2009; Edwards *et al.*, 2017; Ferreira *et al.*, 2018; Rocha *et al.*, 2018).

Restoration will be most effective in these systems if active revegetation or mixed approaches are used (Ciccarese *et al.*, 2012; Gilman *et al.*, 2016; Stanturf *et al.*, 2014), depending on the type of mining that occurs. For instance, Parrotta and Knowles (1999, 2001) showed that mixed commercial species plantings of mostly exotic timber trees were the most productive treatment for basal area development and height growth in areas formerly under bauxite mining. Mixed approaches may include the planting of seedlings of native and/or exotic species, the assistance of natural regeneration, or the establishment of agroforestry systems (Macdonald *et al.*, 2015; Stanturf *et al.*, 2015; Viani *et al.*, 2017). The most commonly used technique beyond natural regeneration is a combination of treating soils to increase fertility and reduce acidity (e.g. with calcium carbonate, nitrogen fertilizer, biochar) and seedling and tree planting (Grossnickle and Ivetić, 2017; Palma and Laurance, 2015; Rodrigues *et al.*, 2019). Studies comparing different restoration approaches highlight how the benefits change according to the restoration targets – while areas planted with commercial tree species accumulate the highest biomass in the first 9-13 years, these are often the least species rich (R. L. Chazdon *et al.*, 2020; Crouzeilles *et al.*, 2016; Parrotta and Knowles, 1999). Planting with a mix of native species could more effectively enhance forest resilience in the long term and reduce the risk of arrested succession (Parrotta and Knowles, 2001).

Below-ground diversity has a significant impact on ecosystem functioning and can play a greater role in restoration of degraded mining systems (Harris, 2009). Positive relationships have been discovered between the diversity of arbuscular mycorrhizal fungi and ecosystem net primary productivity, and between arbuscular mycorrhizal fungal community evenness and ecosystem phosphorus-use efficiency (Lovelock and Ewel, 2005). Among the relevant soil micro-organisms, arbuscular mycorrhizal fungi and ectomycorrhizal fungi can be expected to play a major role during restoration of degraded sites (Caravaca *et al.*, 2002, 2003), yet this role is poorly understood. Recent evidence from restoration in China reveals how above-ground conditions can influence below ground communities during restoration; higher plant diversity encouraged plant-soil feedbacks, resulting in more favorable restoration trajectories (Jia *et al.*, 2020).

The standards and best practices available for pre- and post-mining activities are crucial for restoration. Many Amazonian countries have systematic processes developed for post-mining restoration that include actions such as backfilling mined sites with topsoil and treating and refilling tailing ponds as part of 'close as you go' strategies. For larger mines, enforcement of restoration after mine closure is often tied to environmental and social safeguards from major multilateral financial institutions, such as the Inter-American Development Bank and the World Bank's use of the International Finance Corporation's Performance Standard (PS) 1 ('Assessment and management of environmental and social risks and impacts') and PS6 ('Biodiversity conservation and sustainable management of living natural resources', see World Bank, 2019). However, there is a lack of monitoring, and enforcement of mining policies are weak or non-existent for medium to small-scale operations. Furthermore, there are no schemes to restore areas impacted by illegal mining, which often takes place in remote regions.

28.3.2 Restoration of vegetation on deforested land

The loss of over 865,000 km² of Amazonian primary forests to date (Smith *et al.*, 2021) means that there are many opportunities for forest restoration. These opportunities are greatest in the Brazilian Amazon as (i) it covers 60% of the basin's forested area, and (ii) accounts for 85% of all deforestation to date (Smith *et al.* 2021, Chapter 19). Other notable deforestation hotspots exist in Colombia, Peru, and Bolivia. Within the Brazilian Amazon, 20% of deforested land has been abandoned and is covered by secondary forests; these are concentrated in the 'arc of deforestation' and alongside waterways and major highways (Smith *et al.*, 2020). Further restoration of unproductive farmland in the Brazilian Amazon could be encouraged by the Native Vegetation Protection Law (often referred to as the Forest Code), which requires most rural properties to maintain between 50 and 80% of forest cover on their lands (Nunes *et al.* 2016).

The vast majority of restoration on agricultural lands is passive, where forests are left to return naturally (Chazdon *et al.*, 2016; Smith *et al.*, 2020). Most Amazonian secondary forests resulting from passive restoration are less than 20 years old (Chazdon *et al.*, 2016). Within the Brazilian Amazon, the median age is just seven years, and very young secondary forests (≤5 years old) represent almost half of the total secondary forest extent (Smith *et al.*, 2020). These secondary forests develop for two distinct reasons. First, forest regrowth is a way for farmers to restore soil fertility and reduce weed infestation after agriculture. These forests are often subject to clearance for new agricultural uses, but there may be limited interventions such as the enrichment of the regrowth with useful plant species (e.g. Padoch and Pinedo-Vasquez, 2010). Second, secondary forests develop as the result of abandoning farmland; here, there is no specific objective for high diversity or functioning forests, and normally nothing is done to alter the successional trajectory.

Although naturally regenerating secondary forests are frequently referred to as 'passive' restoration, their recovery could be improved through active management. In some cases, fencing can be important to protect them from livestock (e.g. Griscom *et al.*, 2009; Wassie *et al.*, 2009). Excluding fire is a key priority: secondary forests can be more flammable than primary forests as they are drier and hotter in the daytime (Ray *et al.*, 2005), and burned secondary forests recover at a much slower rate (Heinrich *et al.*, 2021). Secondary forest value will also be enhanced by protecting existing forests, as older forests bring greater benefits for biodiversity conservation (Lennox *et al.*, 2018) and carbon stocks (e.g. Heinrich *et al.*, 2021). Yet, protecting secondary forests from disturbance or clearance remains challenging. They are often considered to be of little value, which may have contributed to an increase in clearance rates in recent decade (Wang *et al.*, 2020). Furthermore, there has been no overall increase in forest cover in Amazonian landscapes that were heavily deforested over 20 years ago (Smith *et al.* 2021). Restoration programs therefore need to develop incentives to protect existing secondary forests and encourage restoration in regions where there is the greatest extent of deforested land.

Active restoration approaches vary, but some of the most popular involve direct seeding of pioneer species, lower density planting of non-pioneer species, as well as plowing and soil preparation (Cruz *et al.*, 2021; Vieira *et al.*, 2021). Despite some successes in highly deforested landscapes (e.g. Vieira *et al.* 2021), active restoration of abandoned farmland will always be difficult and expensive at the very large scales required across the Amazon. For example, a review of over 400 restoration projects in the Brazilian Amazon found that assisted natural regeneration was used in just 3%, while an ambitious and innovative active restoration project that involved multiple communities and up to 450 seed collectors (see Box 1 in Chapter 29) has nonetheless restored just 50 km² of forest (Schmidt *et al.*, 2019), a tiny fraction of the forests developing due to land abandonment over the same period (Smith *et al.*, 2020).

Where active restoration is implemented, species must be carefully chosen. Active restoration should not be restricted to fast-growing pioneers; evidence from the Atlantic forest shows old growth species provide many benefits when planted in open areas (Piotto *et al.*, 2020). The species provenance is important; local seed collection schemes and nurseries are vital to maintain local seed sources and appropriate species mixes, but without long-term co-development of seed collecting schemes (e.g. Schmidt *et al* 2018) there are often limitations regarding the availability of seeds from native species (Nunes *et al.*, 2020). In many ecosystems, restoration should focus on using provenances that reflect future conditions (Breed *et al.*, 2012). However, this is not possible in the lowland tropics, where climate change is creating novel climates without present-day analogues (Williams *et al.*, 2007).

The spatial configuration of active restoration matters. Nurse trees can encourage seed dispersal into restoration areas, and applied nucleation (where planting in small patches encourages forest recovery at larger scales) has proven successful in other parts of the Neotropics (Rodrigues *et al.*, 2019; Zahawi *et al.*, 2013). Some active restoration approaches can even be counter-productive; in the Cerrado, Sampaio *et al.* (2007) demonstrate that intensive restoration efforts in abandoned pasture may actually slow early succession of seasonal deciduous forest. The many challenges of developing and scaling effective active restoration should not detract from the important role it can play in certain contexts. It will be particularly useful when previous land use intensity has been high, if there are few seed sources in the vicinity, or when speeding up the restoration of areas with high social and ecological value such as riparian forests (Schmidt *et al.*, 2019; Vieira *et al.*, 2021).

The ecological benefits of forest restoration are highly variable. For example, there are large differences in estimates of carbon accumulation in passively regenerating lowland Amazonian forests, with estimates ranging from <1 to > 4Mg C ha-1 yr-1 (Poorter *et al.* 2016, Elias *et al.*, 2020). The recovery of biodiversity is also variable. Some studies show strong positive relationships between the recovery of species richness or composition and above-ground carbon or biomass (Ferreira *et al.*, 2018; Gilroy *et al.*, 2014; Lennox *et al.*, 2018). However, this relationship attenuates with increasing biomass levels (Ferreira *et al.* 2018), and older secondary forests (c. 50 years old) may stop accumulating additional species if isolated from primary forests (Elias *et al.* 2020). Furthermore, although secondary forests in favorable contexts can hold a high diversity of fauna and flora, the species composition tends to be very different (Barlow *et al.*, 2007), and many species with restricted ranges only use the oldest secondary forests (Lennox *et al.*, 2018; Moura *et al.*, 2013).

The variation in recovery trajectories of secondary forests reflects the wide range of drivers that affect the recovery process. Climate is a key driver, and forest recovery is slower in drier and more seasonal climates (Elias *et al.*, 2020; Poorter *et al.*, 2016). Differences in previous land use, such as the intensity, frequency, duration, extent, and type, also affect successional pathways (Jakovac *et al.*, 2021). Landscape context can also play a key role in driving recovery (Chapter 29), with proximity to existing forest edges and high forest cover landscapes (Jakovac *et al.* 2021) having strong and positive effects on recovery (Camargo *et al.*, 2020; Leitold *et al.*, 2018).

There is also an important variation in the cost of returning agricultural land to forest. Some costs are associated with restoration actions, such as planting, fencing, etc. However, opportunity costs are also fundamental. Most of the secondary forests that exist do so because farming generates low profits; e.g. (Garrett *et al.*, 2017). Encouraging further restoration in similar regions will therefore have low opportunity costs. However, restoring forests on productive agricultural land with high profit margins will incur much higher costs. Not all actors will be able to bear these costs equally; it is likely that smallholders will face greater challenges if they are required to increase secondary forest coverage or move from farm-fallow systems to permanent areas of restoration. The benefits for local actors could be enhanced where secondary forests provide marketable non-timber forest products (NTFPs), such as fruits, resins, honey, or building materials (Chapter 30).

28.3.3 Restoration of degraded forests

There are many different drivers of forest degradation in the Amazon (Chapter 19). Human-driven disturbances that lead to degradation include selective logging, forest fires, edge effects, and hunting (Asner *et al.*, 2005; Barlow and Peres, 2008; Broadbent *et al.*, 2008; Aragão *et al.*, 2018; Silva Junior *et al.*, 2020; Bogoni *et al.*, 2020). Natural disturbances include extreme droughts and windthrows (Espírito-Santo *et al.*, 2014; Leitold *et al.*, 2018; Phillips *et al.*, 2009). The impact of the disturbance and the degree of degradation is variable. For example, repeated forest fires can eliminate almost all of the original trees, and cause a complete turnover of faunal communities (Barlow and Peres, 2008), while hunting leads to more subtle changes in plant communities that have been detected in longer-term studies of changes in tropical forest species composition (Terborgh *et al.*, 2008; Harrison *et al.*, 2013). Disturbances often co-occur; edges and logged forests are often burned (e.g. Silva Junior *et al.* 2020), and the effects of extensive forest fires are superimposed upon the effects of extreme droughts (Berenguer *et al.*, 2021). When all forms of degradation are assessed together, they can drive as much biodiversity loss as deforestation itself in human modified Amazonian landscapes (Barlow *et al.*, 2016).

Existing large-scale assessments of degradation focus on structural changes in the forest that can be detected by satellites. These suggest that at least 17% of Amazonian forests were degraded by disturbances such as logging, fires, or windthrow between 1995 and 2017 (Bullock *et al.*, 2020). In the Brazilian portion of the basin, this degraded area covers a greater area than that deforested to date (Matricardi *et al.*, 2020). The extent and impacts of cryptic disturbances such as defaunation are far less certain than those of canopy disturbance (Peres *et al.*, 2006). Recent studies estimate a 57% reduction in local fauna across the Neotropics (Bogoni *et al.*, 2020). Within the Amazon, defaunation is highest in the arc of deforestation and the Andes, but even intact areas have lost key species (Bogoni *et al.*, 2020). For example, white-lipped peccary (*Tayassu pecari)* are estimated to be absent from 17% of Brazil's state of Amazonas, despite it retaining 98% of its forest cover (Parry and Peres, 2015). Bushmeat consumption in small urban centers is also prevalent (Parry and Peres, 2015) and can deplete game species for over 100 km from the urban center (Parry and Peres, 2015).

The impacts and longevity of degradation effects mean conservation efforts should first focus on avoiding human-driven disturbances in the first place, retaining as much of the intact forests as possible (Watson *et al.*, 2018). But once a forest has been degraded, the probability of further change provides important insights into management. Crucially, 14% of degraded forests are eventually deforested (Bullock *et al.*, 2020). Avoiding this deforestation is important; although these degraded forests have a lower conservation value and deliver fewer ecosystem services than undisturbed forests, they remain significantly more important for biodiversity and ecosystem functioning than agricultural land uses (Barlow *et al.*, 2016; Berenguer *et al.*, 2014; Edwards *et al.*, 2011).

Bullock *et al.* (2020) also estimate that around 29% of forests that were degraded within the time-scale of the study were degraded again – a number that would be considerably higher if non-structural forms of degradation (such as hunting) were included, or if the assessment was carried out over longer time periods. This demonstrates the importance of avoiding further disturbance events in degraded forests, which is particularly important where disturbances facilitate the occurrence of others or amplify their effects. For example, extreme droughts, selective logging, and edge effects all make forests more susceptible to fires, due to changes in microclimatic conditions and/or fuel loads (Camargo and Kapos, 1995; Ray *et al.*, 2005; Silva Junior *et al.*, 2018; Uhl and Kauffman, 1990). These events can also amplify effects of subsequent degradation, as tree mortality from fire is much higher close to forest edges, or in forests that have been previously logged or burned (Brando, Silvério, *et al.*, 2019; Gerwing, 2002)

Recovery times of degraded forests are highly variable, depending on the type and intensity/severity of the disturbance (Box 1). Recovery rates are also dependent on the metric of interest; for example, logged forests can return to baseline humidity and temperature conditions within a few years, when canopy cover recovers after human-driven disturbance (Mollinari *et al.*, 2019), and some burned forests can quickly recover their capacity to cycle water (Brando, Silvério, *et al.*, 2019). In contrast, carbon stocks are likely to take decades to recover, and may reach an alternative lower biomass state following forest fires (Rutishauser *et al.*, 2015; Silva *et al.*, 2018, 2020). The recovery of species composition and large trees will be even slower (de Avila *et al.*, 2015; Avila *et al.*, 2015); while data on slow events are limited, the slow generation time of the Amazon's largest trees (e.g. Vieira *et al.*, 2005) suggests this could even take millennial time-scales (but see Vidal *et al.*, 2016). Some Amazonian ecosystems appear to be particularly sensitive to disturbance, and may not recover at all; for example, flooded forests enter a state of arrested or impeded succession following forest fires (Flores *et al.*, 2017).

In some contexts, active restoration could assist the recovery of degraded forests. Forests that have burned more than once can lose almost all of their above ground biomass (Barlow and Peres, 2004), and recovery is likely to be impeded by the dominance of vines and bamboos and tree species that are not normally found in primary or later successional forests (Barlow and Peres, 2008). In these forests, or in forests severely damaged by repeated conventional logging, enrichment planting might be a valid approach to improve the ecological condition and societal benefits that can be derived from the forests. Most research on this relates to post-harvesting efforts to improve future timber yield. This research shows that enrichment planting can be effective at small scales when planting has been combined with vine cutting (Keefe *et al.*, 2009) or tending (Schwartz *et al.*, 2013). A study in Borneo shows that active restoration and enrichment can also double carbon uptake over a 20-year time period (Philipson *et al.*, 2020). However, enrichment planting is expensive, difficult to apply at scale, and is only likely to be financially viable under certain economic circumstances (Schulze, 2008; Schwartz *et al.*, 2016). Finally, reintroductions of faunal communities could help reverse species extirpations and restore ecosystem processes, and have been carried out in highly deforested and defaunated ecosystems such as the Atlantic Forest (Genes *et al.*, 2019). Such programs are expensive and challenging, and in most Amazonian regions the terrestrial fauna will be able to recolonize naturally once pressures such as hunting are removed. However, active reintroductions may be worth considering for some of the most fragmented forests, and have been proposed for Woolly Monkeys in the Colombian Amazon (Millán *et al.*, 2014).

The enormous spatial scale and complexity of degradation in the Amazon means the most cost-effective and scalable strategies must focus on avoiding disturbance events in the first place, or prevent reoccurrence. The complex set of human drivers of disturbance means this will involve a broad range of strategies. Some degradation can be avoided by reducing deforestation itself; for example, edge and isolation effects are a direct consequence of forest clearance. Actions to prevent forest fires will involve reducing or controlling ignition sources in the landscape and linking early detection of fires with the rapid deployment of fire combat teams (e.g. Nóbrega Spínola *et al.*, 2020). Avoiding disturbance from illegal and conventional logging will be key, but remains an enormous challenge across the Amazon (Brancalion *et al.*, 2018). Measures addressing activities closely linked to local livelihoods, such as hunting and fire-use in agriculture, will require careful co-development with communities. Management interventions can also try to prevent disturbances from co-occurring. For example, although it may not be possible to prevent climate-driven disturbance without rapid global action on climate change, local management of fires and/or logging could help mitigate their impacts (Berenguer, 2021). Other measures required to reduce or revert degradation are outlined in Chapter 27.

28.3.4 Restoration of sustainable economic activities in deforested lands

In the Amazon basin, opportunities for the restoration of production areas have been established from new or reformed policies to promote environ-

BOX 28.1: Recovery times of anthropogenically degraded forests

Figure B.28.1 Degraded forests in the central Amazon. Photo: Adam Ronan/Rede Amazônia Sustentável (RAS)

Forests affected by selective logging tend to recover their biomass in a timeframe that is almost directly proportional to the biomass removed in the logging process, meaning that on average there would be a 27-year recovery time for a 20% loss of biomass (Rutishauser et al., 2015). However, there are high levels of variation related to soil fertility and climate (Piponiot et al., 2016), and this linear relationship may not hold if the offtake exceeds that permitted by reduced impact techniques. Burned forests are likely to take much longer to recover, as tree mortality continues for many years after the fire (Barlow et al. 2003, Silva et al. 2018). Even low intensity fires in forests that have burned just once lead to 25% reductions in above-ground biomass up to 30 years later, although there are high levels of uncertainty beyond the first 10 years (Silva et al. 2020). Recovery of twice- or thrice-burned forests will be even slower given the very high tree mortality rates (Barlow & Peres, 2008; Brando, Paolucci, et al., 2019). Forest edges (forests within 120 m of a man-made edge) also suffer long-term degradation, with pronounced decreases in above ground biomass in the first five years after edge creation. The longevity of edge effects on forest biomass depends on how the edges are managed; where fires are logging are excluded, species composition changes but biomass levels can approximate interior forests after 22 years (Almeida et al., 2019). However, for most of the Amazon, edges remain exposed to additional disturbances, and biomass levels remain 40% lower than forest interiors 15 years after edge creation (Silva Junior et al., 2020). There is growing evidence that large vertebrates can recover their populations when hunting pressure is alleviated, with increases in game densities following reserve creation. However, group living species such as white-lipped peccaries may take much longer to return to pre-impact levels due to Allee effects (i.e. low individual fitness at low population densities), and recovery will be slower (or even non-existent) in fragmented landscapes where movement and colonization are restricted.

mental protection (Brazil, Lei N° 12.651,de 25 de Maio de 2012; Furumo and Lambin, 2020; Sears *et al.*, 2018; Soares-Filho *et al.*, 2014). Innovative solutions for restoration and sustainable production of food, fiber and other bioproducts in these deforested lands are vital for reconciling inclusive and equitable economic development, in particular at the local level, with environmental conservation in the Amazon basin. The need for the restoration of sustainable and socially-just economic activities in deforested lands is greatest where agriculture is no longer or not yet profitable. There are many landscape-level benefits of this, including increasing overall tree cover, creating space for natural regeneration by increasing productivity (Chazdon *et al.*, 2017), and reducing pressure on natural systems through a forest transition (see Chapter 29). In this section, we focus on the site-level benefits, which include improving the livelihoods and wellbeing of small and medium farmers and traditional communities by enhancing food security, and access to timber and fuel (FAO, 2018; HLPE, 2017). The next paragraphs outline some of the techniques that can be used to meet these aims, focusing on three promising approaches to enhancing productivity: the sustainable intensification of pastures, agroforestry, and improving farm-fallow cropping.

28.3.4.1 Sustainable intensification of pastures

Sustainable intensification, i.e. increasing productivity (of land, labor, and capital, according to the socioeconomic context) while reducing environmental impacts, is particularly relevant on pastures, as extensive cattle ranching based on African grasses (Dias-Filho, 2019; Valentim, 2016; Valentim and de Andrade, 2009) accounts for 89% of the farmed area in the Amazon biome (MAPBIOMAS, 2020) and tends to generate very low or even negative profits (Garrett *et al.* 2017). Productivity rates of these pastures have been estimated to be only 32-34% of their potential (Strassburg *et al.*, 2014). More recently, however, cattle ranching systems are breaking away from the rationale of land occupation and rapid depletion of soil resources that has characterized past decades (Wood *et al.*, 2015). A partial decoupling between cattle production and deforestation has been observed (e.g. (Lapola *et al.*, 2014). Although deforestation has once again increased at the frontier (Smith *et al.* 2021), cattle ranching has become more intensive in the older and more consolidated frontiers of the Brazilian states of Pará and Mato Grosso where there is better access to modern technologies and markets and stronger governance (Schielein and Börner, 2018).

Sustainable intensification of pastures requires effective governance systems that are able to avoid further land conversion and guarantee sustainable development models (Garrett *et al.*, 2018). According to Strassburg *et al.* (2014), increasing the productivity of pastures in the Brazilian Amazon to just 49-52% of their potential would be sufficient to meet national and export demands for meat by 2040, as well as free up land to produce other foods, timber, and biofuels without the need to convert additional areas of native vegetation. This would result in the mitigation of 14.3 GT CO_2e from avoided deforestation.

Technological solutions for sustainable intensification of pastures include changing continuous to rotational grazing associated with increasing pasture productivity (Dias Filho, 2011), adopting mixed grass-legume pastures (Valentim and Andrade, 2004; Zu Ermgassen *et al.*, 2018), and agrosilvipastoral and silvopastoral systems that integrate trees and different agroecosystems (de Sousa *et al.*, 2012; Uphoff *et al.*, 2006; Valentim, 2016). Along with other agroecological approaches, these alternatives are more aligned with regenerative agriculture, as they encompass a set of practices aimed at restoring and maintaining soil quality, supporting biodiversity, protecting watersheds, improving above and belowground linkages and, ultimately, ecological and economic resilience (Bardgett and Wardle, 2010; Ranganathan *et al.*, 2020; White, 2020). For example, these systems could help replace costly nitrogen fertilizer with symbiotically fixed nitrogen by soil bacteria, increase soil quality and agroecosystem resilience, and reduce greenhouse gas emissions per unit of digestible protein produced (Gerssen-Gondelach *et* *al.*, 2017; Gil *et al.*, 2018; Latawiec *et al.*, 2014). Additionally, they could contribute to increase productivity of land, labor, and capital (Martha Jr *et al.*, 2012). Finally, productive pastures can be managed without fire, removing one of the most prevalent ignition sources from the Amazon (see section on forest degradation).

28.3.4.2 Agroforestry

Agroforestry offers another option to regenerate unproductive lands and maintain production on already deforested lands, and is particularly well-suited to smallholder farms. Agroforestry systems integrate the production of trees and crops on the same piece of land, and can sequester carbon in soils and vegetation as a co-benefit (Ranganathan *et al.*, 2020). Agroforestry contributes to more than one third of the restoration efforts identified in the Brazilian Amazon (Cruz et al., 2020) and will provide benefits beyond the area being planted, such as improving the permeability of the landscape for forest biota or mediating landscape temperatures (see also Chapter 29).

Agroforestry systems have a long history in the region as they date back to the domestication of native plants for agriculture in pre-Columbian times (Miller and Nair, 2006; Clement *et al.*, 2015; Iriarte *et al.*, 2020; see Chapter 8). Contemporary agroforests still include many native species, and the most frequently used are those that have strong demand in local, regional, and international markets such as Brazil nuts (*Bertholletia excelsa*), açai (*Euterpe oleracea*), cocoa (*Theobroma cacao*), cupuaçu (*Theobroma grandiflorum*), and peach palm (*Bactris gassipaes*). Agroforestry systems have been widely applied throughout the basin, from Brazil to Bolivia, Colombia, Ecuador, Peru, Suriname, and Venezuela (Porro *et al.*, 2012). Examples of effective agroforestry can be found in the Japanese-Brazilian colonists of Tomé-Açu's Multipurpose Agriculture Cooperative (CAMTA) in the state of Pará (Yamada and Gholz, 2002) and in the Association of Agrosilvicultural Smallholders of the RECA Project (Intercropped and Dense Economic Reforestation) in Rondônia state (Porro *et al.*, 2012; see Chapter 30).

28.3.4.3 Farm fallow systems

Improving farm-fallow systems has vast potential for sustainable economic restoration in the Amazon, as shifting cultivation is a pillar of traditional farming systems and is common across the entire basin. Restoration options in farm-fallow systems include reducing fire-use by adopting chop-and-mulch and other techniques (Denich *et al.*, 2005; Shimizu *et al.*, 2014), and shortening the cropping periods and increasing the fallow period to restore soil and agricultural productivity (Jakovac *et al.*, 2016; Nair, 1993). Extended fallow periods have additional benefits, provided they do not encourage additional clearance; they can help support the conservation of biodiversity and may improve hydrological functions and other ecosystem services (Chazdon and Uriarte, 2016; Ferreira *et al.*, 2018). Enriching the fallow areas with selected species (e.g. nitrogen fixing legumes, or trees with economic value) could improve economic returns, especially when natural regeneration is no longer adequate to re-establish agricultural productivity (Marquardt *et al.*, 2013).

Whichever approach is adopted or encouraged, it is important that the restoration of economic production enhances biological complexity and diversity, instead of promoting uniformity and specialization as a way to control nature and maximize profit (Garrett *et al.*, 2019; HLPE, 2019). But despite advances in knowledge and policies (Nepstad *et al.*, 2014), restoration of sustainable and socially-just economic activities have yet to overcome the barriers that would allow them to be adopted at large-scales in the region (Bendahan *et al.*, 2018; Valentim, 2016). These systems therefore require a paradigm shift in agriculture and rural development, incorporating principles of equity, local participation and empowerment, food sovereignty, and local marketing systems (Bernard and Lux, 2016). It is important to take into account context specificities through adapted technologies, innovations, and transformation pathways that address the multiple functions of agriculture, forests, and rural activities. They thus call for the design of new methods and metrics to assess performance, and the boosting of learning processes involving multiple stakeholders rather than operating through technology transfer. Moreover, restoration of agricultural land in the Amazon requires much better investment in farming design, using tools for mapping land suitability e.g. (Osis *et al.*, 2019), and communal land-use plans e.g. (Pinillos *et al.*, 2020).

28.4 Aquatic restoration techniques and options

Freshwater systems in the Amazon encompass a tremendous variety of environments, ranging from small streams with short-lived, unpredictable spates to large river floodplain mosaics organized by seasonal annual floods. Although we treat aquatic ecosystem restoration separately in this section, there is important overlap with terrestrial and seasonally flooded landscapes which can have profound influences on water quality and the health of aquatic communities (Affonso *et al.*, 2011; Mayorga *et al.*, 2005; Melack *et al.*, 2009; Melack and Forsberg, 2001).

The spatial dispersion of degradation sources can vary greatly across landscapes and riverscapes. Restoration strategies will differ depending on the types and magnitude of degradation, and whether degradation arises from a diffuse set of sources originating over large areas or more concentrated point sources. In general, restoration from point sources, which can be readily targeted, is more an economic and political challenge, rather than a technical challenge (Bunn, 2016). In contrast, restoring waterways degraded by non-point sources is considerably more complicated, and in many cases requires the restoration of vast areas of terrestrial habitats. Thus, restoration of terrestrial and seasonally flooded landscapes will often be the first filter for the successful restoration of Amazonian aquatic ecosystems and their associated biota, as terrestrial and aquatic ecosystems are inextricably linked.

28.4.1 Restoration after pollution

Amazonian water bodies are polluted by myriad sources, including industrial and agricultural pollution, sewage run-off, mercury and other heavy metals from mining, and oil spills (Chapter 20). These pollutants can come from many sources and become widely dispersed across landscapes and riverscapes. Pollution can travel hundreds of miles downstream, so resolving the source can have wide-ranging benefits downstream. While controlling point sources of pollution is technically feasible, economics, poor governance, and lack of appropriate policies pose a challenge. Addressing non-point sources adds further complexity, and in many cases requires integrating restoration across vast areas, including both terrestrial and aquatic habitats (Bunn, 2016). For example, improvements in terrestrial conditions include regulating chemical use in agriculture and improving run off from urban and industrial landscapes. Diffuse pollution is a particular problem in Amazonian aquatic ecosystems surrounded by human settlements. For example, only 12% of cities in the Brazilian Amazon treat sewage (ANA, 2017). Thus, it is noteworthy that while restoration of Amazonian aquatic ecosystems is key, basic wastewater infrastructure needs to be expanded in the first place.

Pollution from oil extraction and mining has received considerable attention because it is widespread, can be particularly pernicious to ecosystems, and affects many people who rely directly on river water for household use (e.g., drinking, bathing) and fish for food (see chapter 21). In terms of oil extraction, areas in the western Amazon have been widely affected by wastewater and waste oil discharge, and are the focus of clean-up efforts (Finer *et al.*, 2015). However, tools developed in temperate zones can be difficult to apply in tropical ecosystems. For example, one of the most successful methods for remediation in temperate regions involves microbial degradation of oil and gas pollutants, but the most commonly available strains are not necessarily suited for the anoxic conditions of many systems in the Amazon (Maddela *et al.*, 2017). Although new strains are being developed, implementation is further challenged by the logistics associated with reaching remote areas, lack of clear remediation standards, lack of accountability, and limited funding (Fraser, 2018).

Mining for gold, aluminum, copper, and other metals can also result in widespread ecosystem degradation with strong implications for human well-being, particularly because they release toxic materials such as mercury (see chapter 20). Active techniques to restore polluted lands involve improving soil conditions by replanting tree species (Gastauer *et al*., 2020) or inoculating soils with degrading microorganisms (Couic *et al*., 2018), but it is not clear how these terrestrially-focused approaches benefit polluted water bodies. In terms of directly restoring water, use of slacked lime for SPM (suspended particulate matter) decantation appears to be an efficient and non-onerous process for gold miners to avoid Hg methylation in tailings ponds when it is combined with rapid drainage of the mine waters (Guedron *et al*., 2011). The addition of litter and seed to tailing ponds located in wetlands, such as *igapó* flooded forests, can also accelerate plant recovery (Dias *et al*., 2011).

Another source of contamination in the Amazon's aquatic ecosystems is plastic (see also Chapter 20), which is increasingly recognized as a serious concern for aquatic food chains (Collard *et al*., 2019; Diepens and Koelmans, 2018; Lacerot *et al*., 2020) and human health (De-la-Torre, 2020). The Amazon is now among the most plastic contaminated rivers in the world, second only to the Yangtze River in China (Giarrizzo *et al*., 2019). Plastic bags, bottles, and other plastic solid waste enter Amazonian rivers, with the mainstream a conduit of plastic pollution to the ocean. Tidal flooded forests in the lower Amazon estuary trap some transported litter, with plastic one of the most significant components (Gonçalves *et al*. 2020). As plastic degrades into smaller microplastic pieces (<5 mm), it enters food chains via ingestion by fish and other consumers. To date, a relatively small number of studies have examined microplastic contamination in the Amazon (Kutralam-Muniasamy *et al*., 2020); however, these existing works help document the enormity of microplastic contamination. A recent study revealed large amounts of microplastics in river sediments around Manaus. Especially high concentrations of microplastics were found in depositional river reaches where backwater effects reduce flow velocities, such as in shallow parts of the lower Rio Negro (Gerolin *et al*., 2020).

Food web analyses in the Xingu River (Andrade *et al*. 2019) and lower Amazon estuary (Pegado *et al*. 2018) indicate ingestion of microplastics by a broad suite of fish species from different trophic groups, and the transmission of microplastics through the food web. In addition to ecological consequences of plastic pollution in Amazonian waters, a grave concern is the threat of microplastic contaminated fish to food security and human health (De-la-Torre 2020). Given the importance of fish to human diets in the Amazon, there is an urgent need to learn more about microplastics and their capacity to act as endocrine disruptors, mutagens, and other human health risks. Mitigating plastic pollution is an enormous global challenge (Jia *et al*. 2019); one initial step is that some Amazonian nations, including Colombia, Ecuador, and Peru, are beginning to develop rules to govern plastics (Ortiz e al. 2020), and Peru has legislated a progressive phase-out of single-use plastic bags (Alvarez-Risco *et al*., 2020).

28.4.2 Dam removal and restoring natural flow cycles and connectivity

Watercourse fragmentation, associated with the construction of dams or other artificial in-stream structures such as culverts, has been identified as one of the main drivers of population declines and reductions in the spatial distribution of freshwater vertebrates (Strayer and Dudgeon, 2010; see Chapter 20). The effects of hydropower dams as barriers to migration and dispersal of aquatic animals are well documented (Anderson *et al*., 2018) and are related to the formation of the reservoir, modification of the natural flow regime downstream of dams, and the blocking of migratory movements (e.g. Baxter, 1977; Poff *et al*., 2007; Val *et al*., 2016). In South America, attempts to minimize their effects on river connectivity are mostly ineffective (Agostinho *et al*., 2008; Pelicice *et al*., 2015; Pompeu *et al*., 2012). Dam removal has arisen as an alternative capable of reversing the impacts generated by dams (Bednarek, 2001; Bernhardt *et al*., 2005), but such a restoration measure is still restricted to a small number of countries, and no case has been reported for the Amazon.

The reasons that justify the removal of a dam depend on the context in which it is inserted (Maclin and Sicchio, 1999), and various barrier removal prioritization methods have been proposed in recent years (Kemp and O'hanley, 2010; O'Hanley *et al.*, 2020). These usually involve comparing the amount of power produced and the associated environmental costs. One example of a dam that would qualify as a priority for removal is the Hydroelectric Power Plant of Balbina, on the Uatumã river in Amazonas state (Brazil). Balbina is responsible for only 10% of the energy consumed by Manaus (a metropolis with around 2 million people), but created a reservoir of more than 2,300 km² and contributed to the displacement and massacre of the Waimiri Atroari Indigenous peoples (Fearnside, 1989). Additionally, methane released from the decomposition of submerged trees and soil organic matter is comparable, in terms of greenhouse gases per unit electricity generated, to a same-sized coal-fired power plant (Kemenes *et al.*, 2007, 2011). In fact, many existing hydropower dams currently in operation in the lowland Amazon are more carbon-intensive than fossil-fueled power plants (R. M. Almeida *et al.*, 2019). Strategically removing some of them may restore ecosystem services and could reduce the greenhouse gas footprint of the region's power sector if they were replaced with alternative ways of producing renewable energy.

Although the removal of hydropower plants in the Amazon seems unlikely in the short and medium term, there is great potential for restoration actions related to the elimination of smaller barriers. Small dams built to provide water for cattle, small-scale fish production, and local hydroelectric power generation are widespread (Souza *et al.* 2019). For example, 10,000 small impoundments have been estimated only in the Upper Xingu Basin in the lower Amazon (Macedo *et al.* 2013). These small impoundments and lentic water bodies are increasing in abundance as deforestation contin-ues. Removing and improving these smaller impoundments and barriers could be a restoration measure that is feasible in socio-economic terms, as it would have minimal impact on farming systems but could have many local benefits, both upstream and downstream, in terms of water quality, flow, and stream biodiversity.

28.4.2.1 Restoring fisheries and curbing overfishing

Fish provide millions of people in the Amazon, from Indigenous peoples to urban populations, with their primary source of protein, omega-3s, and other essential nutrients (Heilpern *et al.*, 2021; Isaac and De Almeida, 2011). Although there are many commercially viable species, the largest and most important fisheries are based on a subset of about 10-18 species groups found in and around the productive floodplains and estuaries (Barthem and Goulding, 2007). In the Amazon River and tributaries, for example, 10 taxa (species groups) contribute to 85% of the multispecies catch in weight (Barthem *et al.*, 2007; Doria *et al.*, 2018).

The restoration of fisheries in the Amazon involves, in part, addressing overfishing problems through the development of sustainable fishing practices. Data has shown that important fishery resources such as the dourada (*Brachyplatystoma rousseauxii*), piramutaba (*Brachyplatystoma vaillantii*,), and tambaqui (*Colossoma macropomum*) are overexploited (e.g., Goulding *et al.*, 2019; Tregidgo *et al.*, 2017). Historical declines in the maximum average size of the main harvested species have been observed throughout the Amazon (a process called "fishing down") (Castello *et al.*, 2013). Overfishing can be avoided by regulating fisheries and improving and implementing enforcement of regulations. Compliance with regulations such as minimum size limits or season closure has been shown to be a major factor in the recovery of overexploited Pirarucu or Paiche (*Arapaima gigas*) populations in the Middle Solimoes-Amazon River floodplain (Castello *et al.*, 2011;Arantes *et al.* 2010). However, enforcement over an area as extensive and complex as the Amazon is very difficult and expensive. In addition, the lack of engagement and participation of users (fishers) has led to widespread free rider problems. Co-management schemes based on sharing property rights and the responsibility of managing resources among local users, the government, and other stakeholders can help overcome these problems. Co-management can also strengthen local organizations, enhance relations among stakeholders, create mechanisms for restricting access (i.e., defining boundaries), create incentives (e.g. marketing strategies), and improve rule enforcement (Arantes *et al.*, 2021).

Co-management schemes developed for *Arapaima gigas* provide an example of how fisheries can achieve successful outcomes when the fishers' community is truly engaged and given rights and responsibilities to manage resources. In some cases, this has resulted in both the increase in the population of *Arapaima gigas*, and stronger fisher participation in the management process, as they benefited from increased monetary returns (Castello *et al.*, 2009). To expand this effort, it is extremely important to strengthen local organizations and enhance relations among stakeholders, as well as create mechanisms for restricting access (i.e., defining boundaries) and incentives (e.g., marketing strategies), and enforce rules and sanction offenders. Assessing average prices practiced in the international market (Barthem and Goulding, 2007) can improve the recognition of the social and economic value of fishing in the region. Improving the market value of fish can also increase the gain to fishers and reduce pressure on stocks.

Because *Arapaima gigas* is a non-migratory species, the community can perceive the benefits of increased local populations. However, to address overfishing problems related to migratory species such as *Brachyplatystoma rousseauxii* and *Colossoma macropomum*, co-management schemes must be implemented over large regions, within a basin-wide framework that should include international treaties (Cruz et al., 2020). Co-management associated with measures such as quota policies and closed seasons with the remuneration of fishermen (such as the *seguro defeso* in Brazil) can play an important additional role (De Almeida *et al.*, 2015). Maintaining fluvial connectivity is also key for the maintenance of their populations (Chapters 20, 27, and 29).

Fish farming has been growing in the Amazon region, encouraged by local governments, to supply a high demand for fish, as well as a management tool to reduce fishing pressure on native stocks. However, industrial aquaculture can compete with artisanal fishing, producing large quantities of fish and placing it more easily in large markets, marginalizing the value of native fish (Pauly, 2018). The benefits of aquaculture are also held by few producers, who can commercialize the products at larger scales than fishing communities. In addition, without adequate controls, aquaculture can be responsible for the introduction of non-native species (Casimiro *et al.*, 2018; Latini *et al.*, 2016; Orsi and Agostinho, 1999). These non-native species can become invasive, changing the structure of native fish populations and ecosystem interactions, thereby affecting human activities such as fishing (Attayde, 2011; Bailly *et al.*, 2008; Bezerra *et al.*, 2019; Coca Méndez *et al.*, 2012; Simberloff and Rejmánek, 2011; Vitule *et al.*, 2009, 2012). Examples include *Araipama gigas* on the upper Madeira River, and tilapia *Oreochromis niloticus* in different regions of the Amazon (Carvajal-Vallejos *et al.*, 2011; Lizarro *et al.*, 2017; Doria *et al.* 2020). Technical options for recovering native stocks could include the elimination of non-native species by encouraging targeted fishing for these species (Britton *et al.*, 2009; Ribeiro *et al.*, 2015).

Lorenzen *et al.* (2013) proposed that controlling fishing effort, habitat (restoration, rehabilitation), and aquaculture-based enhancement are the principal means by which fisheries can be sustained and improved. It is possible that multiplicative gains may be made through a combination of these approaches, but more research is needed to understand the factors contributing to success or failure, and the application of a more methodical and scientific approach to fisheries restoration should be encouraged. We must move away from treating symptoms to developing a systematic approach for collecting and analyzing data, assessing watersheds, identifying critical issues, and formulating watershed plans to address those issues (Taylor *et al.*, 2017).

28.4.2.2 Restoring floodplains

Floodplains are threatened by a combination of stressors, including loss of hydrological connectivity and habitat, both of which have cascading effects on biota and negatively impact local and regional fish production and diversity (Arantes *et al.*, 2019b). Amazonian floodplain ecosystems span about 8.4×10^5 km^2, 14% of the total Amazon Basin (Hess *et al.*, 2015). They are maintained by seasonal inundation cycles, with a flood pulse that remobilizes riverbed sediment and drives lateral exchanges of organic and inorganic materials between river channels and floodplain habitats, thereby influencing biogeochemical cycles and boosting biological production (Junk *et al.* 1989). These floodplains are heterogeneous, dynamic ecosystems that are amongst the most diverse on the planet, including speciose plant communities (e.g., herbaceous and aquatic macrophyte communities, shrubs, and trees) (Junk *et al.*, 2012; Hess *et al.*, 2015). These plants, in particular forests, provide fish and other aquatic organisms with important food resources and seasonal access to critical nursery and refuge habitat (Arantes *et al.*, 2019a; Goulding, 1980). Recent studies have shown forest cover to be positively correlated with fish biomass and diversity and fishery yields (Arantes *et al.*, 2019a; Castello *et al.*, 2018).

Despite their importance, floodplains are threatened by a combination of stressors, including loss of hydrological connectivity and habitat. Several large and small dams are operating and planned for Amazonian floodplains (e.g, Madeira, Xingu, Tapajos), leading to alterations of river hydrology and sediment/nutrient dynamics (Forsberg *et al.*, 2017). Although a basin-wide assessment of deforestation in these ecosystems is still missing, large areas of floodplains in the lower Amazon River alone were deforested for agriculture over the past 40 years (Reno *et al.* 2018). Jute (*Corchorus capsularis*) plantations and cattle ranching resulted in a loss of 56% of floodplain forest cover by 2008 in the lower Amazon (Reno *et al.* 2011), while even forested areas are becoming impoverished by intensification of acai production (Freitas *et al.*, 2015). Changes in hydrology and deforestation have cascading effects on vertebrate assemblages, and negatively impact fish production and diversity at local and regional scales (Arantes *et al.*, 2019a).

Restoring floodplains requires recovering natural flood pulse regimes and connecting floodplains and habitats that are essential for supporting the biodiversity and services these ecosystems sustain. A first step towards a basin-wide management framework is collecting and disseminating data, and likewise, any restoration measures of floodplains will require as reference a standard base on unmodified systems. It is therefore essential to implement and disseminate effective monitoring systems of hydrology and land cover in floodplains across the basin (e.g., based on sensors, satellite images, gauges). Metrics of inter- and intra-annual variability in hydrological connectivity can help provide standards for defining practical measures for recovering connectivity, such as altering design and operational features, or even removing dams (see section 28.4.2).

Floodplain restoration programs can be achieved through collaborative partnerships and stakeholder involvement (McGrath *et al.*, 2008). Examples include initiatives to reforest levees and replant aquatic macrophytes in the Lower Amazon. Discussion among stakeholders was used to help define project aims and planning, select and collect seeds, and produce seedlings (McGrath *et al.*, 2008). Other experiments have been conducted to restore aquatic macrophyte communities on lake margins and surfaces, and to control erosion (Arantes personal comm.; McGrath and Crossa 1998). Unfortunately, these experimental initiatives are often undermined by uncontrolled cattle grazing in the floodplains. Implementing successful floodplain restoration programs therefore requires addressing cattle grazing regulations. It would also benefit from developing engagement programs with fish-

BOX 28.2 Restoration of floodplain forests: the Batata Lake case study

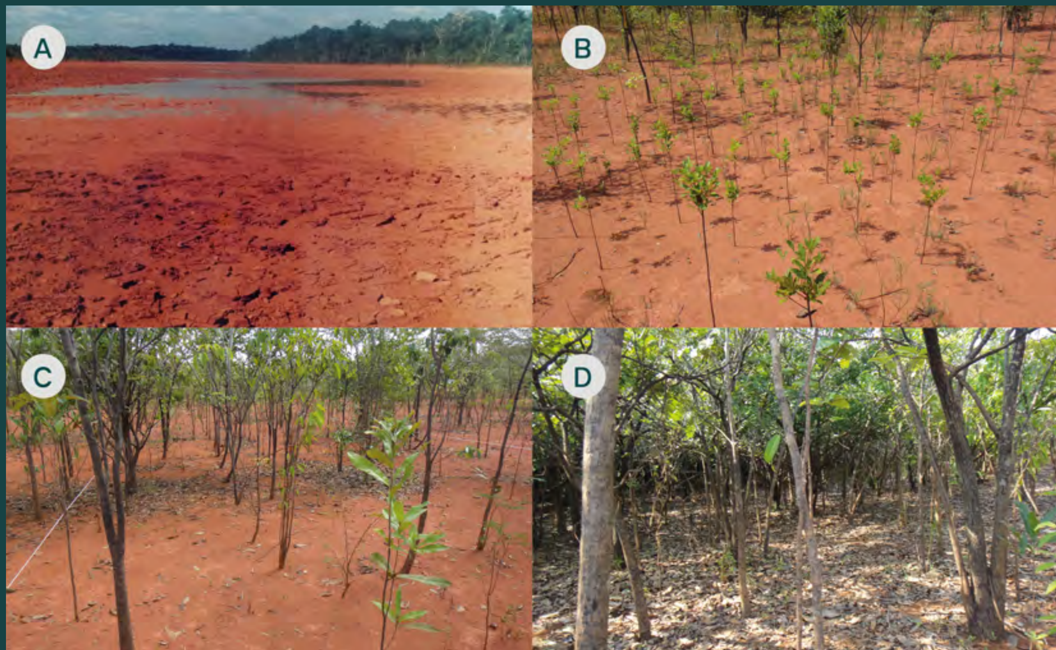


Figure B.28.2. A. Mining sediment in Batata Lake, PA, Brazil, in low water period (December) before the intervention for planting seedlings of igapó species. B. Mining sediment in Batata Lake, PA, Brazil, in low water period (December), planted with igapó species. Larger plants about 15 years old and smaller plants about 2 years old. C. Mining sediment in Batata Lake, PA, Brazil, in low water period (December), planted with igapó species. Larger plants about 20 years old. D. Mining sediment in Batata Lake, PA, Brazil, in low water period (December), planted with igapó species around 20 years old. In addition to closing the canopy, it is possible to observe the recruitment of seedlings and the accumulation of litter on the bauxite tailings, aspects that indicate the sustainability of the planting.

The complexity, high cost, and long-term commitments needed for successful restoration efforts after pollution are demonstrated by Batata Lake, a floodplain ecosystem adjacent to the clear-water Trombetas River in Pará (Brazil). Between 1979 and 1989, millions of cubic meters of bauxite tailings were continually deposited in Batata Lake. As a result, a tailings layer of 2-5 m buried about 600 hectares of the lake, equivalent to ~30% of the lake's area during the flood season, and vast areas of *igapó* vegetation vanished (Bozelli et al., 2000). A long-term restoration program began in the early 1990s and has been ongoing for nearly 30 years; it is considered the largest-scale restoration effort in a seasonally-flooded Amazonian ecosystem (Scarano et al., 2018). Restoration of the newly-deposited sterile substrate was complicated by the low nutrient availability typical of *igapó* ecosystems. As a result, active restoration was undertaken, and approximately half a million individuals of various *igapó* tree species were planted between 1993 and 2005, focusing on the areas where natural regeneration was not occurring. To avoid eutrophication, restoration avoided chemical fertilizers and instead made successful use of litterfall from pristine nearby *igapós* (Dias et al. 2012). By 2018, the combined effect of natural and human-intervened regeneration resulted in the re-establishment of *igapó* vegetation in nearly 70% the impacted area, and the speed of recovery was associated with topography, species introduced, and inundation patterns. However, floristic similarities with native, non-impacted sites remain moderate in most parts of the impacted area; estimates suggest some areas may take over 75 years to restore to levels similar to those of non-impacted *igapó* ecosystems. The multidisciplinary team of experts involved with the restoration efforts contend that species selection, litter and seed addition, and continuous monitoring are key for an accelerated successional trajectory in the restoration of Amazonian *igapó* ecosystems (Scarano et al 2018) ing communities, to understand the challenges whilst increasing awareness of the benefits of recovering floodplain habitats.

28.5 Indicators of success

The broad range of restoration techniques outlined above provide a toolkit for site- and target-specific restoration actions, but how do you evaluate success or failure? This is key to understanding the factors underpinning restoration performance, learning from them in an adaptive manner to inform policies and improve interventions in the future, tracking national commitments made for climate change and biodiversity, and holding businesses to account. But despite the many advantages, such monitoring and evaluation is rarely undertaken in a comprehensive manner in restoration (Murcia *et al.*, 2016; Suding, 2011).

There are a broad range of potential indicators of success (e.g. Ruiz-Jaen and Mitchell Aide, 2005; Stanturf *et al.*, 2015), and they vary greatly in their ease and scalability. For example, open-source platforms such as MapBiomas mean that year-on-year changes in forest cover can be assessed across the Amazon with reasonable accuracy. However, property-level or landscape- and catchment-specific changes will likely require more tailored assessments and higher-resolution imagery (D. R. A. de Almeida *et al.*, 2020). This is especially important when restoration focusses on narrow strips or small patches, including riparian zones; buffers the edges of existing forests; develops agroforestry systems rather than closed-canopy forests; or focusses on aquatic systems, non-forest ecosystems or fauna.

A more detailed understanding of restoration success will require ground-based assessments to evaluate carbon stocks, biodiversity, aquatic condition, or socio-economic values (Wortley *et al.*, 2013). Monitoring might encompass different plant community properties, such as canopy cover, basal area, and density and richness of regenerating plants (Chaves *et al.*, 2015; Suganuma and Durigan, 2015). These indicators are much harder to collect at scale, and they must be defined in a participative way with local stakeholders to ensure their sampling is cost effective, realistic given the expertise and resources available, and sustainable over time (Evans *et al.*, 2018). New technology such as the mobile app Ictio, which is designed to collect standardized information on fisheries from individual users at scale, provides an example of one potential solution. Additional, practical tools using simple criteria should be developed for assessing mandatory restoration projects in the context of public policies (Chaves *et al.*, 2015). Finally, we need to learn from monitoring and evaluation efforts; the information needs to pooled, analyzed, and used to create a comprehensive, evidence-based understanding of effectiveness. This information can also support the development of modeling tools that are able to simulate different scenarios of restoration, providing stakeholders with a means to take the most adequate decision and select the restoration program which best fits their objectives. The inclusion of a diverse range of stakeholders will be essential in this process (Chapter 29)

28.6 Conclusion

There are many opportunities for restoration that are relevant and technically feasible in diverse Amazonian contexts; the Alliance for Restoration in the Amazon has identified 2,773 terrestrial initiatives in the Brazilian Amazon alone, covering around 1,130 km^2 (Alliance for Restoration in the Amazon, 2020). Yet many of the restoration approaches are small scale, with 79% under 5 ha (Alliance for Restoration in the Amazon, 2020). They are also expensive, and face significant challenges with spatial and temporal scalability. Resolving this requires a broad program of investment, dialogue, and prioritization (Alliance for Restoration in the Amazon, 2020), and should always consider priorities and co-benefits across landscapes and the basin (Chapter 29). Finally, restoration should only ever be seen as a last resort. For vast areas of the Amazon, the primary aim should be to avoid the need for future restoration by conserving intact forests and waterbodies (Chapter 27).

28.7 References

Affonso A, Barbosa C, and Novo E. 2011. Water quality changes in floodplain lakes due to the Amazon River flood pulse: Lago Grande de Curuaí (Pará). *Brazilian J Biol* **71**: 601–10.

Agostinho A, Pelicice F, and Gomes L. 2008. Dams and the fish fauna of the Neotropical region: impacts and management related to diversity and fisheries. *Brazilian J Biol* **68**: 1119–32.

Alliance for restoration in the Amazon. 2021. Forest Landscape Restoration in the Amazon Overview and Paths Restoration. In: Celentano D, Jakovac C (Eds). Overview and Paths to Follow.

Almeida DRA, Stark SC, Schietti J, *et al.* 2019. Persistent effects of fragmentation on tropical rainforest canopy structure after 20 yr of isolation. *Ecol Appl* **29**.

Almeida RM, Shi Q, Gomes-Selman JM, *et al.* 2019. Reducing greenhouse gas emissions of Amazon hydropower with strategic dam planning. *Nat Commun* **10**: 1–9.

Almeida D, Stark SC, Valbuena R, *et al.* 2020. A new era in forest restoration monitoring. *Restor Ecol* **28**: 8–11.

Alvarez-Risco A, Rosen MA, and Del-Aguila-Arcentales S. 2020. A New Regulation for Supporting a Circular Economy in the Plastic Industry: The Case of Peru (Short Communication). *J Landsc Ecol* **13**: 1–3.

ANA. 2017. Atlas esgotos: despoluição de bacias hidrográficas. Brasília - DF.

Anderson EP, Jenkins CN, Heilpern S, *et al.* 2018. Fragmentation of Andes-to-Amazon connectivity by hydropower dams. *Sci Adv* **4**: eaao1642.

Aragão LEOC, Anderson LO, Fonseca MG, *et al.* 2018. 21st Century drought-related fires counteract the decline of Amazon deforestation carbon emissions. *Nat Commun* **9**: 536.

Arantes CC, Castello L, Basurto X, *et al.* 2021. Institutional effects on ecological outcomes of community-based management of fisheries in the Amazon. *Ambio*.

Arantes CC, Winemiller KO, Asher A, *et al.* 2019. Floodplain land cover affects biomass distribution of fish functional diversity in the Amazon River. *Sci Rep* **9**: 16684.

Asner GP, Knapp DE, Broadbent EN, *et al.* 2005. Selective logging in the Brazilian Amazon. *Science* **310**: 480–2.

Asner GP, Llactayo W, Tupayachi R, and Luna ER. 2013. Elevated rates of gold mining in the Amazon revealed through high-resolution monitoring. *Proc Natl Acad Sci* **110**: 18454–9.

Attayde JL. 2011. Impactos da introdução da tilápia do Nilo nas pescarias de um reservatório tropical no nordeste do Brasil. *Gestão da Pesca e Ecol* **18**: 437–43.

Avila AL de Ruschel AR, Carvalho JOP de, *et al.* 2015. Medium-term dynamics of tree species composition in response to silvicultural intervention intensities in a tropical rain forest. *Biol Conserv* **191**: 577–86.

Bailly D, Agostinho AA, and Suzuki HI. 2008. Influence of the flood regime on the reproduction of fish species with different reproductive strategies in the Cuiabá River, Upper Pantanal, Brazil. *River Res Appl* **24**: 1218–29.

Bardgett RD and Wardle DA. 2010. Aboveground-belowground linkages: biotic interactions, ecosystem processes, and global change. Oxford University Press.

Barlow J, Gardner TA, Araujo IS, *et al.* 2007. Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. *Proc Natl Acad Sci* **104**: 18555–60.

Barlow J, Lennox GD, Ferreira J, *et al.* 2016. Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. *Nature* **535**: 144–7.

Barlow J and Peres CA. 2008. Fire-mediated dieback and compositional cascade in an Amazonian forest. *Philos Trans R Soc B Biol Sci* **363**: 1787–94.

Barlow J and Peres CA. 2004. Avifaunal responses to single and recurrent wildfires in Amazonian forests. *Ecol Appl* **14**: 1358–73.

Barrios E, Sileshi GW, Shepherd K, and Sinclair F. 2012. Agroforestry and Soil Health: Linking Trees, Soil Biota, and Ecosystem Services. In: Soil Ecology and Ecosystem Services. Oxford University Press.

Barthem R and Goulding M. 2007. Um ecossistema inesperado. A Amazônia revelada pela pesca. Peru: Amazon Conservation Association.

Barthem R, Goulding M, and others. 2007. An unexpected ecosystem: the Amazon as revealed by fisheries. Missouri Botanical Garden Press.

Baxter RM. 1977. Environmental Effects of Dams and Impoundments. *Annu Rev Ecol Syst* **8**: 255–83.

Bednarek AT. 2001. Undamming Rivers: A Review of the Ecological Impacts of Dam Removal. *Environ Manage* **27**: 803–14.

Bendahan AB, Poccard-Chapuis R, Medeiros RD de, *et al.* 2018. Management and labour in an integrated crop-livestock-forestry system in Roraima, Brazilian Amazonia. *Cah Agric* **27**: 25005.

Berenguer E, Ferreira J, Gardner TA, *et al.* 2014. A large-scale field assessment of carbon stocks in human-modified tropical forests. *Glob Chang Biol* **20**: 3713–26.

Berenguer E, Lennox GD, Ferreira J, *et al.* 2021. Tracking the impacts of El Niño drought and fire in human-modified Amazonian forests. *Proc Natl Acad Sci* **118**: e2019377118.

Bernard B and Lux A. 2016. How to feed the world sustainably: an overview of the discourse on agroecology and sustainable intensification. *Reg Environ Chang 2016 175* **17**: 1279–90.

Bernhardt ES. 2005. ECOLOGY: Synthesizing U.S. River Restoration Efforts. *Science* **308**: 636–7.

Bezerra LAV, Freitas MO, Daga VS, *et al.* 2019. A network meta-analysis of threats to South American fish biodiversity. *Fish Fish*: faf.12365.

Bogoni JA, Peres CA, and Ferraz KMPMB. 2020. Extent, intensity and drivers of mammal defaunation: a continental-scale analysis across the Neotropics. *Sci Rep* **10**: 14750.

Bourgoin C, Betbeder J, Couteron P, *et al.* 2020. UAV-based canopy textures assess changes in forest structure from long-term degradation. *Ecol Indic* **115**: 106386.

Bozelli RL, Esteves FDA, and Roland F. Lago Batata: impacto e recuperação de um ecossistema amazônico. Universidade Federal do Rio de Janeiro.

Brancalion PHS, Almeida DRA de, Vidal E, *et al.* 2018. Fake legal logging in the Brazilian Amazon. *Sci Adv* **4**.

Brando PM, Balch JK, Nepstad DC, *et al.* 2014. Abrupt increases in Amazonian tree mortality due to drought-fire interactions. *Proc Natl Acad Sci* **111**: 6347–52.

Brando PM, Paolucci L, Ummenhofer CC, *et al.* 2019. Droughts, Wildfires, and Forest Carbon Cycling: A Pantropical Synthesis. *Annu Rev Earth Planet Sci* **47**: 555–81.

Brando PM, Silvério D, Maracahipes-Santos L, *et al.* 2019. Prolonged tropical forest degradation due to compounding disturbances: Implications for CO 2 and H 2 O fluxes. *Glob Chang Biol* **25**: 2855–68.

Breed MF, Stead MG, Ottewell KM, *et al.* 2013. Which provenance and where? Seed sourcing strategies for revegetation in a changing environment. *Conserv Genet* **14**: 1–10.

Broadbent EN, Asner GP, Keller M, *et al.* 2008. Forest fragmentation and edge effects from deforestation and selective logging in the Brazilian Amazon. *Biol Conserv* **141**: 1745–57.

Bullock EL, Woodcock CE, Souza C, and Olofsson P. 2020. Satellite-based estimates reveal widespread forest degradation in the Amazon. *Glob Chang Biol* **26**: 2956–69.

Bunn SE. 2016. Grand Challenge for the Future of Freshwater Ecosystems. *Front Environ Sci* **4**.

Camargo JLC and Kapos V. 1995. Complex edge effects on soil moisture and microclimate in central Amazonian forest. *J Trop Ecol* **11**: 205–21.

Camargo PHSA, Pizo MA, Brancalion PHS, and Carlo TA. 2020. Fruit traits of pioneer trees structure seed dispersal across distances on tropical deforested landscapes: Implications for restoration (A Hampe, Ed). *J Appl Ecol* **57**: 2329–39.

Caravaca F, Barea JM, Figueroa D, and Roldán A. 2002. Assessing the effectiveness of mycorrhizal inoculation and soil compost addition for enhancing reafforestation with Olea europaea subsp. sylvestris through changes in soil biological and physical parameters. *Appl Soil Ecol* **20**: 107–18.

Caravaca F, Barea JM, Palenzuela J, *et al.* 2003. Establishment of shrub species in a degraded semiarid site after inoculation with native or allochthonous arbuscular mycorrhizal fungi. *Appl Soil Ecol* **22**: 103–11.

Carvajal-Vallejos FM, Paul A. Van Damme, Cordova L, and Coca C. 2011. La introduccion de Arapaima gigas paiche. *Los Peces Y Delfines La Amaz Boliv Hábitats, Potencialidades Y Amenazas*: 367–95.

Casimiro ACR, Garcia DAZ, Vidotto-Magnoni AP, *et al.* 2018. Escapes of non-native fish from flooded aquaculture facilities: the case of Paranapanema River, southern Brazil. *Zoologia* **35**: 1–6.

Castello L, Hess LL, Thapa R, *et al.* 2018. Fishery yields vary with land cover on the Amazon River floodplain. *Fish Fish* **19**: 431–40.

Castello L, McGrath DG, and Beck PSA. 2011. Resource sustainability in small-scale fisheries in the Lower Amazon floodplains. *Fish Res* **110**: 356–64.

Castello L, Viana JP, Watkins G, *et al.* 2009. Lessons from integrating fishers of arapaima in small-scale fisheries management at the Mamirauá Reserve, Amazon. *Environ Manage* **43**: 197–209.

Chaves RB, Durigan G, Brancalion PHS, and Aronson J. 2015. On the need of legal frameworks for assessing restoration projects success: new perspectives from São Paulo state (Brazil). *Restor Ecol* **23**: 754–9.

Chazdon RL, Brancalion PHS, Lamb D, *et al.* 2017. A Policy-Driven Knowledge Agenda for Global Forest and Landscape Restoration. *Conserv Lett* **10**: 125–32.

Chazdon RL, Broadbent EN, Rozendaal DMA, *et al.* 2016. Carbon sequestration potential of second-growth forest regeneration in the Latin American tropics. *Sci Adv* **2**: e1501639.

Chazdon RL, Gutierrez V, Brancalion PHS, *et al.* 2020. Co-Creating Conceptual and Working Frameworks for Implementing Forest and Landscape Restoration Based on Core Principles. *Forests* **11**: 706.

Chazdon RL, Peres CA, Dent D, *et al.* 2009. The Potential for Species Conservation in Tropical Secondary Forests. *Conserv Biol* **23**: 1406–17.

Chazdon RL and Uriarte M. 2016. Natural regeneration in the context of large-scale forest and landscape restoration in the tropics. *Biotropica* **48**: 709–15.

Chazdon R and Brancalion P. 2019. Restoring forests as a means to many ends. *Science* **365**: 24–5.

Ciccarese L, Mattsson A, and Pettenella D. 2012. Ecosystem services from forest restoration: thinking ahead. *New For* **43**: 543–60.

Clement CR, Denevan WM, Heckenberger MJ, *et al.* 2015. The domestication of Amazonia before European conquest. *Proc R Soc B Biol Sci* **282**: 20150813.

Coca Méndez C, Rico López G, Carvajal-Vallejos FM, *et al.* 2012. Cadena de valor del pescado en el norte amazónico de Bolivia: contribución de especies nativas y de una especie introducida (el paiche-Arapaima gigas). *Investig Ambient PIEB*.

Cohen-Shacham E, Walters G, Janzen C, and Maginnis S (Eds). 2016. Nature-based solutions to address global societal challenges. IUCN International Union for Conservation of Nature.

Collard F, Gasperi J, Gabrielsen GW, and Tassin B. 2019. Plastic Particle Ingestion by Wild Freshwater Fish: A Critical Review. *Environ Sci Technol* **53**: 12974–88.

Couic E, Grimaldi M, Alphonse V, *et al.* 2018. Mercury behaviour and C, N, and P biogeochemical cycles during ecological restoration processes of old mining sites in French Guiana. *Environ Sci Process Impacts* **20**: 657–72.

Crouzeilles R, Curran M, Ferreira MS, *et al.* 2016. A global meta-analysis on the ecological drivers of forest restoration success. *Nat Commun* **7**: 11666.

Cruz REA, Kaplan DA, Santos PB, *et al.* 2021. Trends and environmental drivers of giant catfish catch in the lower Amazon River. *Mar Freshw Res* **72**: 647.

Cruz DC da, Benayas JMR, Ferreira GC, *et al.* 2021. An overview of forest loss and restoration in the Brazilian Amazon. *New For* **52**: 1–16.

Sousa SGA de, Wandelli E V, Garcia LC, *et al.* 2012. Sistemas agroflorestais para a agricultura familiar da Amazônia. In: ABC da agricultura Familiar. Embrapa Amazônia Ocidental.

De-la-Torre GE. 2020. Microplastics: an emerging threat to food security and human health. *J Food Sci Technol* **57**: 1601–8.

Denich M, Vlek P, Deabreusa T, *et al.* 2005. A concept for the development of fire-free fallow management in the Eastern Amazon, Brazil. *Agric Ecosyst Environ* **110**: 43–58.

Dias-Filho MB. 2019. Breve histórico das pesquisas em recuperação de pastagens degradas na Amazônia. *Bras{\'\i}lia, DF Embrapa*.

Diepens NJ and Koelmans AA. 2018. Accumulation of Plastic Debris and Associated Contaminants in Aquatic Food Webs.

Environ Sci Technol **52**: 8510–20.
Diringer SE, Feingold BJ, Ortiz EJ, *et al.* 2015. River transport of mercury from artisanal and small-scale gold mining and risks for dietary mercury exposure in Madre de Dios, Peru. *Environ Sci Process Impacts* **17**: 478–87.
Doria CRC, Duponchelle F, Lima MAL, *et al.* 2018. Review of Fisheries Resource Use and Status in the Madeira River Basin (Brazil, Bolivia, and Peru) Before Hydroelectric Dam Completion. *Rev Fish Sci Aquac* **26**: 494–514.
Edwards DP, Larsen TH, Docherty TDS, *et al.* 2011. Degraded lands worth protecting: the biological importance of Southeast Asia's repeatedly logged forests. *Proc R Soc B Biol Sci* **278**: 82–90.
Edwards DP, Massam MR, Haugaasen T, and Gilroy JJ. 2017. Tropical secondary forest regeneration conserves high levels of avian phylogenetic diversity. *Biol Conserv* **209**: 432–9.
Efroymson RA, Nicolette JP, and Suter GW. 2004. A Framework for Net Environmental Benefit Analysis for Remediation or Restoration of Contaminated Sites. *Environ Manage* **34**: 315–31.
Elias F, Ferreira J, Lennox GD, *et al.* 2020. Assessing the growth and climate sensitivity of secondary forests in highly deforested Amazonian landscapes. *Ecology* **101**.
Espírito-Santo FDB, Gloor M, Keller M, *et al.* 2014. Size and frequency of natural forest disturbances and the Amazon forest carbon balance. *Nat Commun* **5**: 3434.
Evans K, Guariguata MR, and Brancalion PHS. 2018. Participatory monitoring to connect local and global priorities for forest restoration. *Conserv Biol* **32**: 525–34.
Fagan ME, Reid JL, Holland MB, *et al.* 2020. How feasible are global forest restoration commitments? *Conserv Lett* **13**.
FAO. 2018. Future of food and agriculture 2018: Alternative pathways to 2050. Food and Agriculture ORG.
Fearnside PM. 2005. Deforestation in Brazilian Amazonia: history, rates, and consequences. *Conserv Biol* **19**: 680–8.
Fearnside PM. 1989. Brazil's Balbina Dam: Environment versus the legacy of the Pharaohs in Amazonia. *Environ Manage* **13**: 401–23.
Ferreira J, Lennox GD, Gardner TA, *et al.* 2018. Carbon-focused conservation may fail to protect the most biodiverse tropical forests. *Nat Clim Chang* **8**: 744–9.
Finer M, Babbitt B, Novoa S, *et al.* 2015. Future of oil and gas development in the western Amazon. *Environ Res Lett* **10**: 024003.
Flores BM, Holmgren M, Xu C, *et al.* 2017. Floodplains as an Achilles' heel of Amazonian forest resilience. *Proc Natl Acad Sci* **114**: 4442–6.
Forsberg BR, Melack JM, Dunne T, *et al.* 2017. The potential impact of new Andean dams on Amazon fluvial ecosystems. *PLoS One* **12**: e0182254.
Fraser B. 2018. Peru's oldest and largest Amazonian oil field poised for clean up. *Nature* **562**: 18–9.
Freitas MAB, Vieira ICG, Albernaz ALKM, *et al.* 2015. Floristic impoverishment of Amazonian floodplain forests managed for açaí fruit production. *For Ecol Manage* **351**: 20–7.
Furumo PR and Lambin EF. 2020. Scaling up zero-deforestation initiatives through public-private partnerships: A look inside post-conflict Colombia. *Glob Environ Chang* **62**: 102055.
Gann GD, McDonald T, Walder B, *et al.* 2019. International principles and standards for the practice of ecological restoration. Second edition. *Restor Ecol* **27**.
Garrett RD, Koh I, Lambin EF, *et al.* 2018. Intensification in agriculture-forest frontiers: Land use responses to development and conservation policies in Brazil. *Glob Environ Chang* **53**: 233–43.
Garrett RD, Levy S, Carlson KM, *et al.* 2019. Criteria for effective zero-deforestation commitments. *Glob Environ Chang* **54**: 135–47.
Garrett RD, Gardner TA, Morello TF, *et al.* 2017. Explaining the persistence of low income and environmentally degrading land uses in the Brazilian Amazon. *Ecol Soc* **22**: art27.
Gastauer M, Cavalcante RBL, Caldeira CF, and Nunes S de S. 2020. Structural Hurdles to Large-Scale Forest Restoration in the Brazilian Amazon. *Front Ecol Evol* **8**: 593557.
Genes L, Fernandez FAS, Vaz-de-Mello FZ, *et al.* 2019. Effects of howler monkey reintroduction on ecological interactions and processes. *Conserv Biol* **33**: 88–98.
Gerolin CR, Pupim FN, Sawakuchi AO, *et al.* 2020. Microplastics in sediments from Amazon rivers, Brazil. *Sci Total Environ* **749**: 141604.
Gerssen-Gondelach SJ, Lauwerijssen RBG, Havlík P, *et al.* 2017. Intensification pathways for beef and dairy cattle production systems: Impacts on GHG emissions, land occupation and land use change. *Agric Ecosyst Environ* **240**: 135–47.
Gerwing JJ. 2002. Degradation of forests through logging and fire in the eastern Brazilian Amazon. *For Ecol Manage* **157**: 131–41.
Giarrizzo T, Andrade MC, Schmid K, *et al.* 2019. Amazonia: the new frontier for plastic pollution. *Front Ecol Environ* **17**: 309–10.
Gil JDB, Garrett RD, Rotz A, *et al.* 2018. Tradeoffs in the quest for climate smart agricultural intensification in Mato Grosso, Brazil. *Environ Res Lett* **13**: 64025.
Gilman AC, Letcher SG, Fincher RM, *et al.* 2016. Recovery of floristic diversity and basal area in natural forest regeneration and planted plots in a Costa Rican wet forest. *Biotropica* **48**: 798–808.
Gilroy JJ, Woodcock P, Edwards FA, *et al.* 2014. Cheap carbon and biodiversity co-benefits from forest regeneration in a hotspot of endemism. *Nat Clim Chang* **4**: 503–7.
Goulding M. 1980. The fishes and the forest: Explorations in Amazonian natural history [Brazil]. Univ of California Press.
Goulding M, Venticinque E, Ribeiro ML de B, *et al.* 2019. Ecosystem-based management of Amazon fisheries and wetlands. *Fish Fish* **20**: 138–58.
Griscom HP, Griscom BW, and Ashton MS. 2009. Forest Regeneration from Pasture in the Dry Tropics of Panama: Effects of Cattle, Exotic Grass, and Forested Riparia. *Restor Ecol* **17**: 117–26.
Grossnickle S and Ivetić V. 2017. Direct Seeding in Reforestation – A Field Performance Review. *REFORESTA*: 94–142.
Guedron S, Grimaldi M, Grimaldi C, *et al.* 2011. Amazonian former gold mined soils as a source of methylmercury: Evidence from a small scale watershed in French Guiana. *Water Res* **45**: 2659–69.
Harris J. 2009. Soil Microbial Communities and Restoration Ecology: Facilitators or Followers? *Science* **325**: 573–4.

Harrison RD, Tan S, Plotkin JB, *et al.* 2013. Consequences of defaunation for a tropical tree community (V Novotny, Ed). *Ecol Lett* **16**: 687–94.

Heilpern SA, Fiorella K, Cañas C, *et al.* 2021. Substitution of inland fisheries with aquaculture and chicken undermines human nutrition in the Peruvian Amazon. *Nat Food* **2**: 192–7.

Heinrich VHA, Dalagnol R, Cassol HLG, *et al.* 2021. Large carbon sink potential of secondary forests in the Brazilian Amazon to mitigate climate change. *Nat Commun* **12**: 1785.

Herrera-R GA, Oberdorff T, Anderson EP, *et al.* 2020. The combined effects of climate change and river fragmentation on the distribution of Andean Amazon fishes. *Glob Chang Biol* **26**: 5509–23.

Hess LL, Melack JM, Affonso AG, *et al.* 2015. Wetlands of the Lowland Amazon Basin: Extent, Vegetative Cover, and Dual-season Inundated Area as Mapped with JERS-1 Synthetic Aperture Radar. *Wetlands* **35**: 745–56.

HLPE. 2017. High Level Panel of Experts. 2017. Nutrition and food systems. *Comm o World Food Secur* **44**: 1–152.

HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. *A Rep by High Lev Panel Expert Food Secur Nutr Comm World Food Secur*: 1–162.

Iriarte J, Robinson M, Souza J de, *et al.* 2020. Geometry by Design: Contribution of Lidar to the Understanding of Settlement Patterns of the Mound Villages in SW Amazonia. *J Comput Appl Archaeol* **3**: 151–69.

Isaac VJ and Almeida MC. 2011. El Consumo de pescado en la Amazonía brasileña.

Jakovac CC, Junqueira AB, Crouzeilles R, *et al.* 2021. The role of land-use history in driving successional pathways and its implications for the restoration of tropical forests. *Biol Rev* **96**: 1114–34.

Jakovac CC, Peña-Claros M, Mesquita RCG, *et al.* 2016. Swiddens under transition: Consequences of agricultural intensification in the Amazon. *Agric Ecosyst Environ* **218**: 116–25.

Jia P, Liang J, Yang S, *et al.* 2020. Plant diversity enhances the reclamation of degraded lands by stimulating plant–soil feedbacks (P De Frenne, Ed). *J Appl Ecol* **57**: 1258–70.

Jia, L., Evans, S., & van der Linden, S. (2019). Motivating actions to mitigate plastic pollution. Nature communications, 10(1), 1-3.

Junk WJ, Piedade MTF, Schöngart J, and Wittmann F. 2012. A classification of major natural habitats of Amazonian whitewater river floodplains (várzeas). *Wetl Ecol Manag* **20**: 461–75.

Kalamandeen M, Gloor E, Johnson I, *et al.* 2020. Limited biomass recovery from gold mining in Amazonian forests. *J Appl Ecol* **57**: 1730–40.

Kalamandeen M, Gloor E, Mitchard E, *et al.* 2018. Pervasive Rise of Small-scale Deforestation in Amazonia. *Sci Rep* **8**: 1600.

Keefe K, Schulze MD, Pinheiro C, *et al.* 2009. Enrichment planting as a silvicultural option in the eastern Amazon: Case study of Fazenda Cauaxi. *For Ecol Manage* **258**: 1950–9.

Kemenes A, Forsberg BR, and Melack JM. 2011. CO 2 emissions from a tropical hydroelectric reservoir (Balbina, Brazil). *J Geophys Res* **116**: G03004.

Kemenes A, Forsberg BR, and Melack JM. 2007. Methane release below a tropical hydroelectric dam. *Geophys Res Lett* **34**.

Kemp PS and O'hanley JR. 2010. Procedures for evaluating and prioritising the removal of fish passage barriers: a synthesis. *Fish Manag Ecol*: no-no.

Kutralam-Muniasamy G, Pérez-Guevara F, Elizalde-Martínez I, and Shruti VC. 2020. Review of current trends, advances and analytical challenges for microplastics contamination in Latin America. *Environ Pollut* **267**: 115463.

Lacerot G, Lozoya JP, and Teixeira de Mello F. 2020. Plásticos en ecosistemas acuáticos: presencia, transporte y efectos. *Ecosistemas* **29**.

Lamb D, Erskine PD, and Parrotta JA. 2005. Restoration of degraded tropical forest landscapes. *Science* **310**: 1628–32.

Lapola DM, Martinelli LA, Peres CA, *et al.* 2014. Pervasive transition of the Brazilian land-use system. *Nat Clim Chang* **4**: 27–35.

Latawiec AE, Strassburg BBN, Valentim JF, *et al.* 2014. Intensification of cattle ranching production systems: socioeconomic and environmental synergies and risks in Brazil. *Animal* **8**: 1255–63.

Latini AO, Oporto LT, Lima-Júnior DP, *et al.* 2016. Espécies Exóticas Invasoras de Águas Continentais no Brasil.

Laurance WF, Goosem M, and Laurance SGW. 2009. Impacts of roads and linear clearings on tropical forests. *Trends Ecol Evol* **24**: 659–69.

Leitold V, Morton DC, Longo M, *et al.* 2018. El Niño drought increased canopy turnover in Amazon forests. *New Phytol* **219**: 959–71.

Lennox GD, Gardner TA, Thomson JR, *et al.* 2018. Second rate or a second chance? Assessing biomass and biodiversity recovery in regenerating Amazonian forests. *Glob Chang Biol* **24**: 5680–94.

Lizarro D, Torres L, Rodal PA, and Moreno-Aulo F. 2017. Primer registro del paiche, Arapaima gigas (Schinz 1822)(Osteoglossiformes: Arapaimidae) en el r{\'\i}o Mamoré, Beni (Bolivia). *Ecol en Boliv* **52**: 33–7.

Lobo F, Costa M, Novo E, and Telmer K. 2016. Distribution of Artisanal and Small-Scale Gold Mining in the Tapajós River Basin (Brazilian Amazon) over the Past 40 Years and Relationship with Water Siltation. *Remote Sens* **8**: 579.

Lorenzen K, Agnalt A-L, Blankenship HL, *et al.* 2013. Evolving Context and Maturing Science: Aquaculture-Based Enhancement and Restoration Enter the Marine Fisheries Management Toolbox. *Rev Fish Sci* **21**: 213–21.

Lovelock CE and Ewel JJ. 2005. Links between tree species, symbiotic fungal diversity and ecosystem functioning in simplified tropical ecosystems. *New Phytol* **167**: 219–28.

Macdonald SE, Landhäusser SM, Skousen J, *et al.* 2015. Forest restoration following surface mining disturbance: challenges and solutions. *New For* **46**: 703–32.

Maclin E and Sicchio M. 1999. Dam removal success stories. In: Restoring Rivers Through Selective Removal of Dams That Don't Make Sense. Washington, D. C.: American Rivers, Friends of the Earth, and Trout Unlimited.

Maddela NR, Scalvenzi L, and Venkateswarlu K. 2017. Microbial degradation of total petroleum hydrocarbons in crude oil: a field-scale study at the low-land rainforest of Ecuador. *Environ Technol* **38**: 2543–50.

Mansourian S. 2018. In the eye of the beholder: Reconciling interpretations of forest landscape restoration. *L Degrad Dev* **29**:

2888–98.
Marquardt K, Milestad R, and Salomonsson L. 2013. Improved fallows: a case study of an adaptive response in Amazonian swidden farming systems. *Agric Human Values* **30**: 417–28.
Martha GB, Alves E, and Contini E. 2012. Land-saving approaches and beef production growth in Brazil. *Agric Syst* **110**: 173–7.
Matricardi EAT, Skole DL, Costa OB, *et al.* 2020. Long-term forest degradation surpasses deforestation in the Brazilian Amazon. *Science* **369**: 1378–82.
Mayorga E, Aufdenkampe AK, Masiello CA, *et al.* 2005. Young organic matter as a source of carbon dioxide outgassing from Amazonian rivers. *Nature* **436**: 538–41.
McCracken SF and Forstner MRJ. 2014. Oil Road Effects on the Anuran Community of a High Canopy Tank Bromeliad (Aechmea zebrina) in the Upper Amazon Basin, Ecuador (DL Roberts, Ed). *PLoS One* **9**: e85470.
McGrath DG, Cardoso A, Almeida OT, and Pezzuti J. 2008. Constructing a policy and institutional framework for an ecosystem-based approach to managing the Lower Amazon floodplain. *Environ Dev Sustain* **10**: 677–95.
Melack, J. M., and Forsberg, B. R. (2001). Biogeochemistry of Amazon floodplain. Biogeochem. Amaz. Basin; Oxford Univ. Press New York, NY, USA, 235.
Melack JM, Novo EMLM, Forsberg BR, *et al.* 2009. Floodplain ecosystem processes
Millán JF, Bennett SE, and Stevenson PR. 2014. Notes on the Behavior of Captive and Released Woolly Monkeys (Lagothrix lagothricha): Reintroduction as a Conservation Strategy in Colombian Southern Amazon. In: The Woolly Monkey. New York, NY: Springer New York.
Miller RP and Nair PKR. 2006. Indigenous Agroforestry Systems in Amazonia: From Prehistory to Today. *Agrofor Syst* **66**: 151–64.
Mollinari MM, Peres CA, and Edwards DP. 2019. Rapid recovery of thermal environment after selective logging in the Amazon. *Agric For Meteorol* **278**: 107637.
Moura NG, Lees AC, Andretti CB, *et al.* 2013. Avian biodiversity in multiple-use landscapes of the Brazilian Amazon. *Biol Conserv* **167**: 339–48.
Murcia C, Guariguata MR, Andrade Á, *et al.* 2016. Challenges and Prospects for Scaling-up Ecological Restoration to Meet International Commitments: Colombia as a Case Study. *Conserv Lett* **9**: 213–20.
Nair PKR. 1994. An Introduction to Agroforestry. Springer Science and Business Media.
Negrón-Juárez RI, Chambers JQ, Guimaraes G, *et al.* 2010. Widespread Amazon forest tree mortality from a single cross-basin squall line event. *Geophys Res Lett* **37**: n/a-n/a.
Nepstad D, McGrath D, Stickler C, *et al.* 2014. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* **344**: 1118–23.
Nóbrega Spínola J, Soares da Silva MJ, Assis da Silva JR, *et al.* 2020. A shared perspective on managing Amazonian sustainable-use reserves in an era of megafires (AB Leverkus, Ed). *J Appl Ecol* **57**: 2132–8.
Nunes S, Gardner T, Barlow J, *et al.* 2016. Compensating for past deforestation: Assessing the legal forest surplus and deficit of the state of Pará, eastern Amazonia. *Land use policy* **57**: 749–58.
Nunes S, Gastauer M, Cavalcante RBL, *et al.* 2020. Challenges and opportunities for large-scale reforestation in the Eastern Amazon using native species. *For Ecol Manage* **466**: 118120.
O'Hanley JR, Pompeu PS, Louzada M, *et al.* 2020. Optimizing hydropower dam location and removal in the São Francisco river basin, Brazil to balance hydropower and river biodiversity tradeoffs. *Landsc Urban Plan* **195**: 103725.
Orsi ML and Agostinho ÂA. 1999. Introdução de espécies de peixes por escapes acidentais de tanques de cultivo em rios da Bacia do Rio Paraná, Brasil. *Rev Bras Zool* **16**: 557–60.
Osis R, Laurent F, and Poccard-Chapuis R. 2019. Spatial determinants and future land use scenarios of Paragominas municipality, an old agricultural frontier in Amazonia. *J Land Use Sci* **14**: 258–79.
Padoch C and Pinedo-Vasquez M. 2010. Saving Slash-and-Burn to Save Biodiversity. *Biotropica* **42**: 550–2.
Palma AC and Laurance SGW. 2015. A review of the use of direct seeding and seedling plantings in restoration: what do we know and where should we go? (R Marrs, Ed). *Appl Veg Sci* **18**: 561–8.
Palmer MA, Filoso S, and Fanelli RM. 2014. From ecosystems to ecosystem services: Stream restoration as ecological engineering. *Ecol Eng* **65**: 62–70.
Parrotta, John A.; Wildburger, Christoph; and Mansourian, Stephanie. (eds.). 2012. Understanding relationships between biodiversity, carbon, forests and people: The key to achieving REDD+ objectives. A global assessment report prepared by the Global Forest Expert Panel on Biodiversity,Forest Management, and REDD+. IUFRO World Series Volume 31. Vienna. 161 p.
Parrotta JA and Knowles OH. 1999. Restoration of Tropical Moist Forests on Bauxite-Mined Lands in the Brazilian Amazon. *Restor Ecol* **7**: 103–16.
Parrotta JA and Knowles OH. 2001. Restoring tropical forests on lands mined for bauxite: Examples from the Brazilian Amazon. *Ecol Eng* **17**: 219–39.
Parry L and Peres CA. 2015. Evaluating the use of local ecological knowledge to monitor hunted tropical-forest wildlife over large spatial scales. *Ecol Soc* **20**: art15.
Pauly D. 2018. The future of artisanal fishing Fishing Lessons: Artisanal Fisheries and the Future of Our Oceans Kevin M. Bailey University of Chicago Press, 2018. 252 pp. *Science* **360**: 161–161.
Pelicice FM, Pompeu PS, and Agostinho AA. 2015. Large reservoirs as ecological barriers to downstream movements of Neotropical migratory fish. *Fish Fish* **16**: 697–715.
Peres CA, Barlow J, and Laurance WF. 2006. Detecting anthropogenic disturbance in tropical forests. *Trends Ecol Evol* **21**: 227–9.
Pettorelli N, Barlow J, Stephens PA, *et al.* 2018. Making rewilding fit for policy (M Nuñez, Ed). *J Appl Ecol* **55**: 1114–25.
Philipson CD, Cutler MEJ, Brodrick PG, *et al.* 2020. Active restoration accelerates the carbon recovery of human-modified tropical forests. *Science* **369**: 838–41.
Phillips OL, Aragão LEOC, Lewis SL, *et al.* 2009. Drought Sensitivity of the Amazon Rainforest. *Science* **323**: 1344–7.
Pinillos D, Bianchi FJJA, Poccard-Chapuis R, *et al.* 2020.

Understanding Landscape Multifunctionality in a Post-forest Frontier: Supply and Demand of Ecosystem Services in Eastern Amazonia. *Front Environ Sci* **7**.
Piotto D, Flesher K, Nunes ACP, *et al.* 2020. Restoration plantings of non-pioneer tree species in open fields, young secondary forests, and rubber plantations in Bahia, Brazil. *For Ecol Manage* **474**: 118389.
Piponiot C, Sist P, Mazzei L, *et al.* 2016. Carbon recovery dynamics following disturbance by selective logging in Amazonian forests. *Elife* **5**: e21394.
Poff NL, Olden JD, Merritt DM, and Pepin DM. 2007. Homogenization of regional river dynamics by dams and global biodiversity implications. *Proc Natl Acad Sci* **104**: 5732–7.
Pompeu P dos S, Agostinho AA, and Pelicice FM. 2012. Existing and future challenges: the concept of successful fish passage in South America. *River Res Appl* **28**: 504–12.
Poorter L, Bongers F, Aide TM, *et al.* 2016. Biomass resilience of Neotropical secondary forests. *Nature* **530**: 211–4.
Porro R, Miller RP, Tito MR, *et al.* 2012. Agroforestry in the Amazon Region: A Pathway for Balancing Conservation and Development
Putz FE and Redford KH. 2010. The importance of defining 'forest': Tropical forest degradation, deforestation, long-term phase shifts, and further transitions. *Biotropica* **42**: 10–20.
RAISG. 2020. Amazonia Under Pressurewww.amazoniasocioambiental.org. Viewed
Ranganathan J, Waite R, Searchinger T, and Zionts J. 2020. Regenerative Agriculture: Good for Soil Health, but Limited Potential to Mitigate Climate Change. *Worl d Resour Inst*.
Ray D, Nepstad D, and Moutinho P. 2005. Micrometeorological and canopy controls of fire susceptibility in a forested Amazon landscape. *Ecol Appl* **15**: 1664–78.
Rocha R, Ovaskainen O, López-Baucells A, *et al.* 2018. Secondary forest regeneration benefits old-growth specialist bats in a fragmented tropical landscape. *Sci Rep* **8**: 3819.
Rodrigues SB, Freitas MG, Campos-Filho EM, *et al.* 2019. Direct seeded and colonizing species guarantee successful early restoration of South Amazon forests. *For Ecol Manage* **451**: 117559.
Ruiz-Jaen MC and Mitchell Aide T. 2005. Restoration Success: How Is It Being Measured? *Restor Ecol* **13**: 569–77.
Rutishauser E, Hérault B, Baraloto C, *et al.* 2015. Rapid tree carbon stock recovery in managed Amazonian forests. *Curr Biol* **25**: R787–8.
Sampaio, G., Nobre, C., Costa, M. H., Satyamurty, P., Soares-Filho, B. S., and Cardoso, M. (2007). Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. Geophys. Res. Lett. 34, L17709. doi:10.1029/2007GL030612.
Sasaki N and Putz FE. 2009. Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements. *Conserv Lett* **2**: 226–32.
Scarano FR, Bozelli RL, Dias ATC, *et al.* 2018. Twenty-Five Years of Restoration of an Igapó Forest in Central Amazonia, Brazil. In: Igapó (Black-water flooded forests) of the Amazon Basin. Cham: Springer International Publishing.
Schielein J and Börner J. 2018. Recent transformations of land-use and land-cover dynamics across different deforestation frontiers in the Brazilian Amazon. *Land use policy* **76**: 81–94.
Schmidt IB, Urzedo DI, Piña-Rodrigues FCM, *et al.* 2019. Community-based native seed production for restoration in Brazil – the role of science and policy (H Pritchard, Ed). *Plant Biol* **21**: 389–97.
Smith, C. C., Healey, J., Berenguer, E., Young, P. J., Taylor, B., Elias, F., et al. (2021). Old-growth forest loss and secondary forest recovery across Amazonian countries. Environ. Res. Lett. doi:10.1088/1748-9326/AC1701.Santos-Francés F, García-Sánchez A, Alonso-Rojo P, et al. 2011. Distribution and mobility of mercury in soils of a gold mining region, Cuyuni river basin, Venezuela. J Environ Manage 92: 1268–76.
Schulze M. 2008. Technical and financial analysis of enrichment planting in logging gaps as a potential component of forest management in the eastern Amazon. *For Ecol Manage* **255**: 866–79.
Schwartz G, Bais A, Peña-Claros M, *et al.* 2016. Profitability of silvicultural treatments in logging gaps in the Brazilian Amazon. *J Trop For Sci*.
Schwartz G, Lopes JCA, Mohren GMJ, and Peña-Claros M. 2013. Post-harvesting silvicultural treatments in logging gaps: A comparison between enrichment planting and tending of natural regeneration. *For Ecol Manage* **293**: 57–64.
Sears RR, Cronkleton P, Polo Villanueva F, *et al.* 2018. Farm-forestry in the Peruvian Amazon and the feasibility of its regulation through forest policy reform. *For Policy Econ* **87**: 49–58.
Seddon N, Turner B, Berry P, *et al.* 2019. Grounding nature-based climate solutions in sound biodiversity science. *Nat Clim Chang* **9**: 84–7.
Shimizu MK, Kato OR, FIGUEIREDO R de O, *et al.* 2014. Agriculture without burning: restoration of altered areas with chop-and-mulch sequential agroforestry systems in the Amazon region. *Embrapa Amaz Orient em periódico indexado*.
Silva Junior CHL, Aragão LEOC, Anderson LO, *et al.* 2020. Persistent collapse of biomass in Amazonian forest edges following deforestation leads to unaccounted carbon losses. *Sci Adv* **6**: eaaz8360.
Silva CVJ, Aragão LEOC, Young PJ, *et al.* 2020. Estimating the multi-decadal carbon deficit of burned Amazonian forests. *Environ Res Lett* **15**: 114023.
Silva CVJ, Aragão LEOC, Barlow J, *et al.* 2018. Drought-induced Amazonian wildfires instigate a decadal-scale disruption of forest carbon dynamics. *Philos Trans R Soc B Biol Sci* **373**: 20180043.
Simberloff D and Rejmánek M. 2011. Encyclopedia of biological invasions. Univ of California Press.
Smith MN, Taylor TC, Haren J van, *et al.* 2020. Empirical evidence for resilience of tropical forest photosynthesis in a warmer world. *Nat Plants* **6**: 1225–30.
Soares-Filho B, Rajao R, Macedo M, *et al.* 2014. Cracking Brazil's Forest Code. *Science* **344**: 363–4.
Sonter LJ, Herrera D, Barrett DJ, *et al.* 2017. Mining drives extensive deforestation in the Brazilian Amazon. *Nat Commun* **8**: 1013.
Soulé M and Noss R. 1998. Rewilding and biodiversity: complementary goals for continental conservation. *Wild Earth* **8**: 18–28.
Stanturf JA, Palik BJ, and Dumroese RK. 2014. Contemporary

forest restoration: A review emphasizing function. *For Ecol Manage* **331**: 292–323.

Stanturf JA, Kant P, Lillesø J-PB, *et al.* 2015. Forest landscape restoration as a key component of climate change mitigation and adaptation. International Union of Forest Research Organizations (IUFRO) Vienna, Austria.

Strassburg BBN, Latawiec AE, Barioni LG, *et al.* 2014. When enough should be enough: Improving the use of current agricultural lands could meet production demands and spare natural habitats in Brazil. *Glob Environ Chang* **28**: 84–97.

Strayer DL and Dudgeon D. 2010. Freshwater biodiversity conservation: recent progress and future challenges. *J North Am Benthol Soc* **29**: 344–58.

Suding KN. 2011. Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead. *Annu Rev Ecol Evol Syst* **42**: 465–87.

Suganuma MS and Durigan G. 2015. Indicators of restoration success in riparian tropical forests using multiple reference ecosystems. *Restor Ecol* **23**: 238–51.

Taylor PG, Cleveland CC, Wieder WR, *et al.* 2017. Temperature and rainfall interact to control carbon cycling in tropical forests (L Liu, Ed). *Ecol Lett* **20**: 779–88.

Terborgh J, Nuñez-Iturri G, Pitman NCA, *et al.* 2008. Tree recruitment in an empty forest. *Ecology* **89**: 1757–68.

Thompson ID, Ferreira J, Gardner T, *et al.* 2012. Forest biodiversity, carbon and other ecosystem services: relationships and impacts of deforestation and forest degradation. *IUFRO World Ser Vol 31 p 21-51* **31**: 21–50.

Tregidgo DJ, Barlow J, Pompeu PS, *et al.* 2017. Rainforest metropolis casts 1,000-km defaunation shadow. *Proc Natl Acad Sci* **114**: 8655–9.

Uhl C and Kauffman JB. 1990. Deforestation, Fire Susceptibility, and Potential Tree Responses to Fire in the Eastern Amazon. *Ecology* **71**: 437–49.

Uphoff N, Ball AS, Fernandes E, *et al.* 2006. Biological approaches to sustainable soil systems. CRC Press.

Val AL, Fearnside PM, and Almeida-Val VMF. 2016. Environmental disturbances and fishes in the Amazon. *J Fish Biol* **89**: 192–3.

Valentim JF. 2016. Desafios e estratégias para recuperação de pastagens degradadas e intensificação da pecuária a pasto na Amazônia Legal. In: Embrapa Acre-Artigo em anais de congresso (ALICE).

Valentim JF and Andrade CMS de. 2004. Perspectives of grass-legume pastures for sustainable animal production in the tropics. In: Embrapa Acre-Artigo em anais de congresso (ALICE). Reunião Annual Da Sociedade Brasileira De Zootecnia.

Veldman JW. 2016. Clarifying the confusion: old-growth savannahs and tropical ecosystem degradation. *Philos Trans R Soc B Biol Sci* **371**: 20150306.

Viani RAG, Holl KD, Padovezi A, *et al.* 2017. Protocol for Monitoring Tropical Forest Restoration. *Trop Conserv Sci* **10**: 194008291769726.

Vidal E, West TAP, and Putz FE. 2016. Recovery of biomass and merchantable timber volumes twenty years after conventional and reduced-impact logging in Amazonian Brazil. *For Ecol Manage* **376**: 1–8.

Vieira DLM, Rodrigues S, Jakovac CC, *et al.* 2021. Active Restoration Initiates High Quality Forest Succession In A Deforested Landscape In Amazonia. *Res Sq*.

Vieira S, Trumbore S, Camargo PB, *et al.* 2005. Slow growth rates of Amazonian trees: Consequences for carbon cycling. *Proc Natl Acad Sci* **102**: 18502–7.

Vitule JRS, Freire CA, and Simberloff D. 2009. Introduction of non-native freshwater fish can certainly be bad. *Fish Fish* **10**: 98–108.

Vitule JRS, Skóra F, and Abilhoa V. 2012. Homogenization of freshwater fish faunas after the elimination of a natural barrier by a dam in Neotropics. *Divers Distrib* **18**: 111–20.

Wang Y, Ziv G, Adami M, *et al.* 2020. Upturn in secondary forest clearing buffers primary forest loss in the Brazilian Amazon. *Nat Sustain* **3**: 290–5.

Wantzen K and Mol J. 2013. Soil Erosion from Agriculture and Mining: A Threat to Tropical Stream Ecosystems. *Agriculture* **3**: 660–83.

Wassie A, Sterck FJ, Teketay D, and Bongers F. 2009. Effects of livestock exclusion on tree regeneration in church forests of Ethiopia. *For Ecol Manage* **257**: 765–72.

Watson JEM, Evans T, Venter O, *et al.* 2018. The exceptional value of intact forest ecosystems. *Nat Ecol Evol* **2**: 599–610.

White C. 2020. Why Regenerative Agriculture? *Am J Econ Sociol* **79**: 799–812.

Williams JW, Jackson ST, and Kutzbach JE. 2007. Projected distributions of novel and disappearing climates by 2100 AD. *Proc Natl Acad Sci* **104**: 5738–42.

Wood CH, Tourrand J-F, and Toni F. 2015. Pecuária, uso da terra e desmatamento na Amazônia: um estudo comparativo do Brasil, do Equador e do Peru. Editora UnB.

World Bank Group. 2019. Environmental and Social Standards (ESS).https://www.worldbank.org/en/projects-operations/environmental-and-social-framework/brief/environmental-and-social-standards. Viewed

Wortley L, Hero J-M, and Howes M. 2013. Evaluating Ecological Restoration Success: A Review of the Literature. *Restor Ecol* **21**: 537–43.

Yamada M and Gholz HL. 2002. An evaluation of agroforestry systems as a rural development option for the Brazilian Amazon. *Agrofor Syst* **55**: 81–7.

Zahawi RA, Holl KD, Cole RJ, and Reid JL. 2013. Testing applied nucleation as a strategy to facilitate tropical forest recovery (C Banks-Leite, Ed). *J Appl Ecol* **50**: 88–96.

zu Ermgassen E, Alcântara M, Balmford A, *et al.* 2018. Results from On-The-Ground Efforts to Promote Sustainable Cattle Ranching in the Brazilian Amazon. *Sustainability* **10**: 1301.

Chapter 29

Restoration priorities and benefits within landscapes and catchments and across the Amazon basin in the Amazon

Rio Parima na Terra Indígena Yanomami (Foto: Bruno Kelly/Amazônia Real)

INDEX

KEY MESSAGES **3**
29.1. INTRODUCTION **4**
29.2. PRIORITIZING RESTORATION ACTIONS ACROSS THE AMAZON BASIN **4**
29.2.1. CONSERVATION OF THE AMAZON'S THREATENED SPECIES AND UNIQUE ECOSYSTEMS 4
29.2.3 GLOBAL AND BIOME-WIDE CLIMATE BENEFITS 6
29.2.4. SOCIETAL BENEFITS 9
29.3. LANDSCAPE AND CATCHMENT APPROACHES TO RESTORATION AND CONSERVATION **10**
29.3.1. INTEGRATING AQUATIC AND TERRESTRIAL SYSTEMS 10
29.3.2. IMPROVING LANDSCAPE AND CATCHMENT CONNECTIVITY FOR BIODIVERSITY 12
29.3.3. LOCAL CLIMATE BENEFITS 13
29.3.4. REDUCING THE RISK OF SOCIO-ENVIRONMENTAL DISASTERS 13
28.3.5. MEETING MULTIPLE AIMS AND OPTIMIZING BENEFITS 14
29.4. ENCOURAGING A BROADER FOREST TRANSITION **14**
29.5. ENSURING BROADER SOCIETAL BENEFITS FROM RESTORATION **16**
29.6. THE CLIMATE RESILIENCE OF RESTORATION OPTIONS **17**
29.6.1. CLIMATE RESILIENCE OF TERRESTRIAL RESTORATION 17
29.6.2. CLIMATE RESILIENCE OF AQUATIC RESTORATION 19
29.7. ACHIEVING MEANINGFUL RESTORATION AT SCALE **19**
29.7.1. ENFORCEMENT AND MONITORING 20
29.7.2. INCENTIVE-BASED MEASURES 20
29.7.3. COMMUNITY-LED RESTORATION 20
29.8. CONCLUSION **21**
29.9. REFERENCES **21**

Graphical Abstract

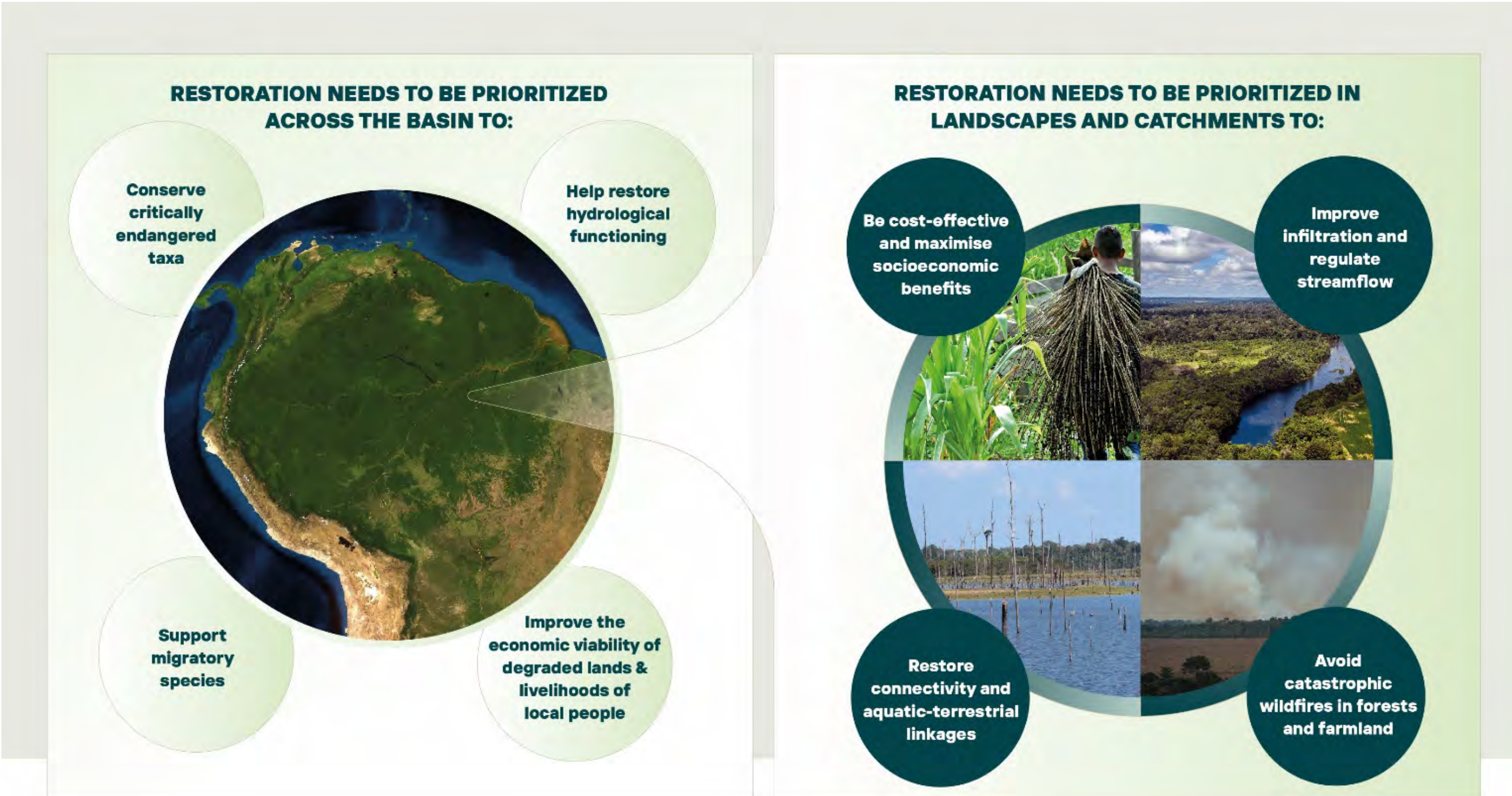


Figure 29.A Graphical Abstract

Restoration Priorities and Benefits within Landscapes and Catchments and Across the Amazon Basin

Jos Barlow[a], Plinio Sist[bc]*, Rafael Almeida[d], Caroline C. Arantes[e], Erika Berenguer[1,f], Patrick Caron[c], Francisco Cuesta[g], Carolina R. C. Doria[h], Joice Ferreira[i], Alexander Flecker[j], Sebastian Heilpern[j], Michelle Kalamandeen[k], Alexander C. Lees[l], Nathália Nascimento[m], Camille Piponiot[n], Paulo Santos Pompeu[o], Carlos Souza[p], Judson F. Valentim[q]*

Key Messages

- Identifying priority locations for restoration across the Amazon Basin is highly dependent on the objectives (e.g. increasing carbon stocks or conserving threatened species). These priority regions must be identified through participatory approaches involving local peoples and governments, supported by up-to-date scientific evidence.
- Considering where and how to restore at the catchment or landscape scale can help return much higher social and ecological benefits than simple site-based approaches.
- Implementing restoration at the landscape and catchment scale must consider a broad range of restoration options, from encouraging the natural regeneration of secondary forests to restoring economic activities in degraded lands. This will help ensure restoration delivers the greatest benefits to the broadest range of stakeholders.
- Restoring ecosystems in the context of climate change requires rebuilding ecosystems that are resilient to higher temperatures, droughts, and climate extremes.
- Restoration strategies will be more effective if they involve complementary conservation measures, such as the protection of remaining natural forests and free flowing rivers (see Chapter 27).
- For long-term success, restoration policies and programs must generate socioeconomic benefits for local populations (e.g., food security, employment, and income opportunities) and raise awareness of the benefits that forests and other natural systems provide

Abstract

Restoration can be applied in many different Amazonian contexts but will be most effective at leveraging environmental and social benefits when it is prioritized across the Amazon Basin and within landscapes

[a] Lancaster Environment Centre, Lancaster University, Lancaster, UK, jos.barlow@lancaster.ac.uk
[b] Agricultural Research Centre for International Development – France. CIRAD, sist@cirad.fr
[c] University of Montpellier, Cirad, Umr ART-DEV, Montpellier 34398, France.
[d] Department of Ecology and Evolutionary Biology, Cornell University, USA.
[e] Division of Forestry and Natural Resources, 325G Percival Hall, 1145 Evansdale Drive, West Virginia University, Morgantown, WV 26506.
[f] Environmental Change Institute, University of Oxford, Oxford, UK.
[g] Grupo de Investigación en Biodiversidad, Medio Ambiente y Salud - BIOMAS - Universidad de Las Américas (UDLA), Quito, Ecuador
[h] Laboratório de Ictiologia e Pesca, Departamento de Ciências Biológicas, Universidade Federal de Rondônia (UNIR), Porto Velho, Brazil
[i] Embrapa Amazonia Oriental, Trav. Eneas Pinheiro, Belém, Brazil.
[j] Department of Natural Resources, Cornell University, 226 Mann Drive, Ithaca NY 14853, USA
[k] School of Geography, University of Leeds, Leeds, UK.
[l] Department of Natural Sciences, Manchester Metropolitan University, UK
[m] Universidade Federal do Espírito Santo - UFES, Instituto de Estudos Climáticos, Vitória, Espírito Santo, Brazil.
[n] Smithsonian Conservation Biology Institute & Smithsonian Tropical Research Institute
[o] Departamento de Ecologia e Conservação, Instituto de Ciências Naturais, Universidade Federal de Lavras, Lavras, MG, Brazil.
[p] Instituto do Homem e Meio Ambiente da Amazônia (IMAZON), Trav. Dom Romualdo de Seixas 1698, Edifício Zion Business 11th Floor, Bairro Umarizal, Belém PA 66055-200, Brazil
[q] Agroforestry Research Center of Acre, Embrapa Acre, Rodovia BR-364, Km 14 (Rio Branco/Porto Velho), Rio Branco AC 69900-970, Brazil

and catchments. Here we outline the considerations that are most relevant for planning and scaling restoration.

Keywords: Conservation planning, prioritization, succession

29.1. Introduction

When restoration has been identified as an important action to achieve a particular target (e.g., Chapter 28), the first tier of prioritization involves identifying which areas to restore. Across ecosystems, systematic conservation planning aims to support decision making regarding the allocation of resources (Margules and Pressey 2000). These approaches have been widely used to help identify priority areas for conservation or restoration across the world (e.g., Strassburg *et al.* 2020) and within catchments (e.g. Beechie *et al.* 2008; McIntosh *et al.* 2017). In this chapter, we go beyond the specific restoration options outlined in Chapter 28 to examine benefits of planning conservation across the basin, in catchments, and in landscapes. We then outline how restoration can be used to encourage a favorable forest cover transition in the Amazon, before outlining some of the crucial societal benefits. Finally, we explore the resilience of restoration to climate change, and examine measures which could help encourage large-scale restoration across the Amazon.

29.2. Prioritizing restoration actions across the Amazon Basin

Despite a growing number of global and ecosystem level prioritization exercises (Crouzeilles *et al.* 2020; Strassburg *et al.* 2020), very few formal analyses exist prioritizing restoration actions across the Amazon Basin or identifying optimal scenarios to realize multiple aims. Here we outline some of the key ecological and societal benefits that could be attained from a large-scale, basin-wide restoration program.

29.2.1. Conservation of the Amazon's threatened species and unique ecosystems

Habitat loss is the main cause of biodiversity loss globally and it is not surprising that the most threatened forest-dependent birds in the Amazon have distributions coinciding with the most de-forested and degraded regions such as Andean slopes and the "Arc of Deforestation" (Bird *et al.* 2010). In these regions, restoration could play a key role in supporting the conservation of forest-dependent species (Figure 29.1), including the recently rediscovered Belem Curassow *Crax [fasciolata] pinima* (Alteff *et al.* 2019), Black-winged Trumpeter *Psophia obscura*, and the Kaapori capuchin *Cebus kaapori*, which was only described in 1992. All of these species are Critically Endangered according to the IUCN's Red List of Threatened Species. However, the priority in these regions is avoiding further deforestation and degradation by protecting existing forests from logging and forest fires (Chapter 27; Silva Junior *et al.* 2020). This needs to be accompanied by measures that reduce hunting pressure, by tackling commercial hunting and illegal trade, providing alternative livelihoods to communities dependent on bushmeat, changing cultural attitudes, encouraging community-based management with local benefits such as from ecotourism (Bragagnolo *et al.* 2019) or even incentivizing alternative hunting practices such as using dogs that are less likely to affect the rarest arboreal species (Constantino 2019).

While the Critically Endangered and/or range-restricted Amazonian species are an urgent conservation priority, some widely distributed species of conservation concern could also be supported by large-scale restoration. These include large and charismatic vertebrates such as the Near-Threatened Harpy eagle *Harpia harpyja* and Jaguar *Panthera onca* and the Vulnerable White-lipped peccary *Tayassu pecari* (BirdLife International 2021, IUCN Red List for birds, IUCN Red list 2020). While these species also require alternative interventions across the basin to reduce hunting pressure and persecution (Chapter 27), their populations would

Figure 29.1 Six of Amazonia's Red Listed vertebrates. The Critically Endangered (1) Belem Curassow *Crax [fasciolata] pinima*, (2) Black-winged Trumpeter *Psophia [viridis] obscura*, (3) and Kaapori Capuchin *Cebus kaapori*, the Vulnerable (4) White-lipped peccary *Tayassu pecari* and the Near Threatened (5) Harpy Eagle *Harpia harpyja* and (6) Jaguar *Panthera onca*. Photo credits: 1. Surama Pereira, 2. Pablo Cerqueira, 3. Pablo Cerqueira, 4. André Ravetta, 5. Sidnei Dantas, 6. Fernanda Santos

also benefit from restoration actions that help reconnect remaining forests and important habitat areas such as flooded forests. Actions that allow degraded forests to recover will also be key, as they will improve keystone resources such as fruiting trees that are vital for wide ranging species such as the White-lipped peccary, or a viable prey base for apex predators such as the Harpy eagle and Jaguar.

Species-based restoration actions in the Amazon also needs to consider the different habitat types within the biome. Some of these hold distinct biota, most notably white sand forests (Guilherme *et al.* 2018), bamboo-dominated forests of the southwestern Amazon (Kratter 1997), *várzea* and *igapó* forests (Haugaasen and Peres 2007), and savanna enclaves (De Carvalho and Mustin 2017) (see Figure 29.2). These ecosystems are both diverse and unique in their own right and can hold high levels of endemicity. Some of these ecosystems are even yielding new species discoveries; the Near Threatened Campina Jay (*Cyanocorax hafferi*) was only discovered in 2002 and is endemic to *campina* enclaves in and around the Madeira-Purus interfluve. It is well known that afforestation of open habitats, including oil palm expansion in savannas, can have negative consequences for biodiversity (Fernandes *et al.* 2016) and it is vital that conservation and restoration efforts protect the integrity of Amazonian savannas and other unique habitat types (Lees *et al.* 2014).

29.2.2. Improved functional connectivity of river systems

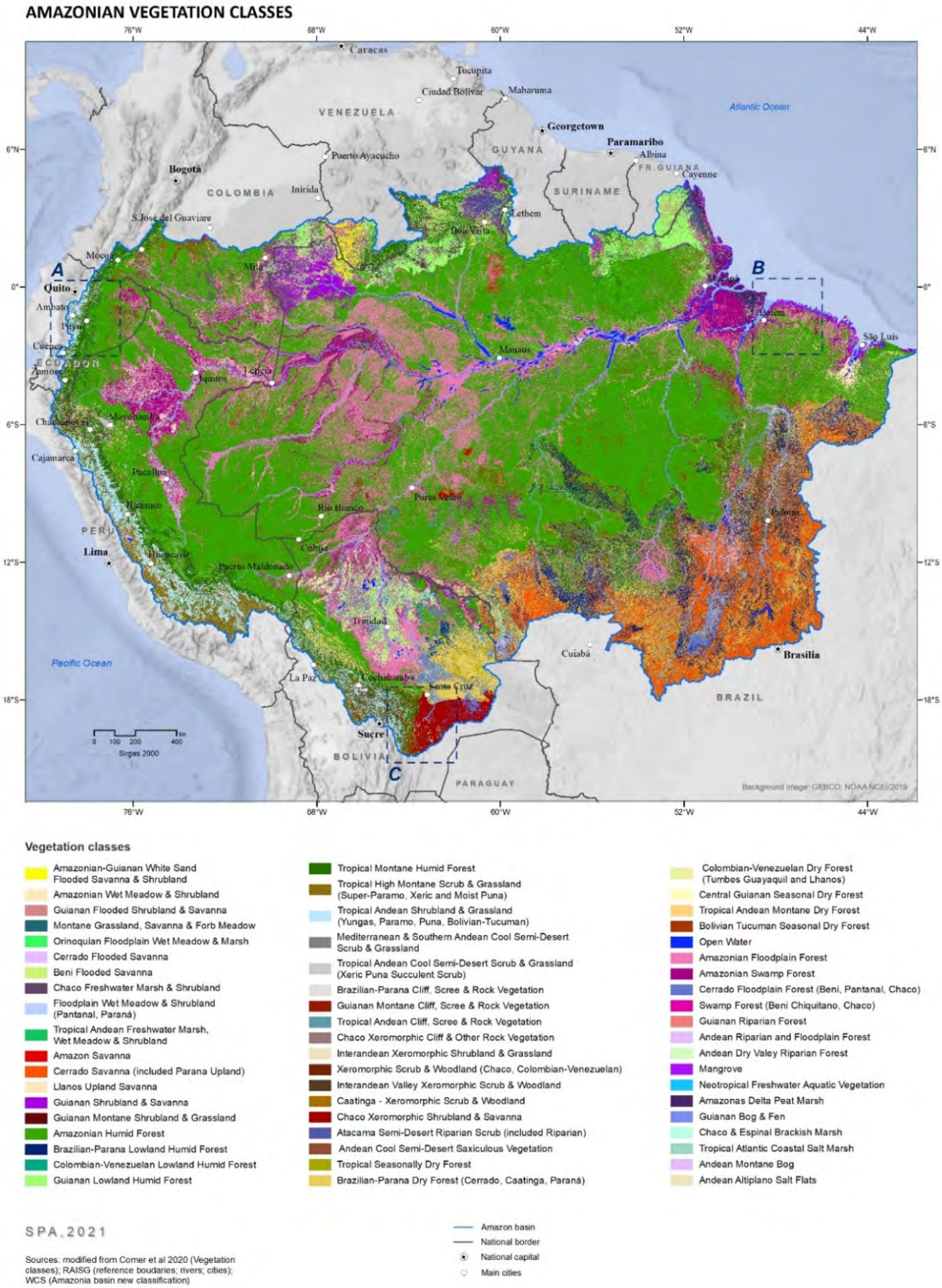
One vital advantage of a basin-wide approach is that the integrity of river systems relies on a high degree of spatial connectivity that operates in multiple dimensions; that is, longitudinally (upstream-downstream), laterally (river channels-riparian zones-floodplains), and vertically (surface-subsurface-groundwater) (Ward, 1989; Castello and Macedo, 2016). Further, seasonal and interannual flows represent a temporal fourth dimension of connectivity. The river continuum concept (Vannote *et al.* 1980) and the flood pulse concept (Junk *et al.* 1989), two foundational paradigms describing riverine and floodplain structure and function, are premised on the importance of longitudinal and lateral connectivity as central organizing features of energy flows, food web structure, and nutrient dynamics of running water systems. Freshwater ecosystems display an acute dependency on subsidies of materials, nutrients, and organisms that originate from elsewhere in the riverscape and landscape, and restoration efforts need to ensure these material and organismal transfers are not disrupted by barriers (Freeman *et al.* 2003; Flecker *et al.* 2010). Likewise, maintenance of natural flow (Poff *et al.* 1997) and sediment regimes (Wohl *et al.* 2015) are fundamental for the functioning of rivers and floodplains. For example, sediments that build Amazon floodplains are transported long distances from their source of origin in the Andes (McClain and Naiman, 2008). Thus, restoring aquatic ecosystems to more natural states involve supporting the vital multi-dimensional linkages that are found throughout river basins, as well as sustaining the organisms embedded in these systems. Such restoration needs to focus on the full hydrological network, from headwaters through to the main channels.

29.2.3 Global and biome-wide climate benefits

Adding up to 24 million ha of forest across the world every year until 2030 could store around one-quarter of the atmospheric carbon necessary to limit global warming to 1.5°C above pre-industrial levels (Hoegh-Guldberg *et al.* 2018). Natural forest regrowth following complete or nearly complete removal of forest vegetation can therefore play a significant role in climate change mitigation (Chazdon *et al.* 2016a; Lewis *et al.* 2019; Cook-Patton *et al.* 2020). For example, the 2.4 Mha of secondary forests in tropical Latin America could accumulate a total aboveground carbon stock of 8.48 Pg C (petagrams of carbon) in 40 years (Chazdon *et al.* 2016b). This is equivalent to all the carbon emissions from fossil fuel use and industrial processes across all Latin America and the Caribbean from 1993 to 2014 (Chazdon *et al.* 2016).

Where climate change mitigation is a priority, restoration will be most effective on a per hectare basis if it occurs where growth rates are fastest – which is generally in the less seasonal regions and in the western Amazon where soils are more productive (Heinrich *et al.* 2021), and where the previous land-use intensity was low (Jakovac *et al.* 2015). However, to date most deforestation has occurred in seasonally dry regions of the Amazon, and, as a result, most secondary forests (and also most opportunities for large-scale restoration) are in regions that are more seasonal, have suffered higher land use intensities, and have low levels of remaining forests cover (Smith *et al.* 2020). For example, secondary forests in the Brazilian Amazon have a mean annual precipitation of 1,945 mm, compared to the regional average of 2,224 mm, while their average maximum climatic water deficit is −375.5 mm compared to a regional average of −259 mm (Smith *et al.* 2020). In the drier and most deforested regions, carbon accumulation rates of secondary forests are some of the lowest in the Amazon (Elias *et al.* 2020; Heinrich *et al.* 2021) with rates of just 1.08 $Mg{\cdot}ha^{-1}{\cdot}yr^{-1}$ compared to rates of 2.2 to >4 $Mg{\cdot}ha^{-1}{\cdot}yr^{-1}$ for studies in other regions (Elias *et al.* 2020).

However, this does not mean that these regions should not be a priority for restoration, as the slow growth is offset by the higher availability of land for restoration, and the lower opportunity costs of conducting restoration on degraded farmland that is often unprofitable (Garrett *et al.* 2017). Furthermore, forest restoration in highly deforested areas may be more important for biodiversity and climatic benefits; new forest fragments may act as important habitat for threatened species, facilitate their dispersal, or buffer remaining primary forests, and the increase in forest cover can potentially increase local rainfall (see section 3.3). The importance of these opportunities for restoration are recognized within climate change targets – for example, the Brazilian state of Pará aims to restore up to 7 million hectares of forest as part of its “Plano Estadual de Amazonia Agora”, helping it achieve carbon neutrality by 2035 (Pará State Decree 941/2020).


AMAZONIAN VEGETATION CLASSES
76°W
68°W
60°W
52°W
44°W
6°N
0°
6°S
12°S
18°S
Caracas
Tucupita
Ciudad Bolívar
Mabaruma
VENEZUELA
Georgetown
Paramaribo
Albina
Cayenne
FR. GUIANA
Atlantic Ocean
GUYANA
SURINAME
Puerto Ayacucho
Bogotá
COLOMBIA
Inírida
S.José del Guaviare
Lethem
Boa Vista
Mocoa
Mitú
A
B
Quito
Ambato
Puyo
Cuenca
Zamora
ECUADOR
Macapá
Belém
São Luis
Manaus
Iquitos
Leticia
Chachapoyas
Moyobamba
Cajamarca
Pucallpa
Huánuco
Porto Velho
Rio Branco
Palmas
PERU
Lima
Cobija
Huancayo
Puerto Maldonado
Trinidad
Pacific Ocean
Cuiabá
Brasilia
La Paz
Cochabamba
Santa Cruz
BRAZIL
Sucre
BOLIVIA
C
PARAGUAY
0 100 200 400 km
Sirgas 2000
Background image: GEBCO; NOAA NCEI/2019
Vegetation classes
Amazonian-Guianan White Sand Flooded Savanna & Shrubland
Amazonian Wet Meadow & Shrubland
Guianan Flooded Shrubland & Savanna
Montane Grassland, Savanna & Forb Meadow
Orinoquian Floodplain Wet Meadow & Marsh
Cerrado Flooded Savanna
Beni Flooded Savanna
Chaco Freshwater Marsh & Shrubland
Floodplain Wet Meadow & Shrubland (Pantanal, Paraná)
Tropical Andean Freshwater Marsh, Wet Meadow & Shrubland
Amazon Savanna
Cerrado Savanna (included Parana Upland)
Llanos Upland Savanna
Guianan Shrubland & Savanna
Guianan Montane Shrubland & Grassland
Amazonian Humid Forest
Brazilian-Parana Lowland Humid Forest
Colombian-Venezuelan Lowland Humid Forest
Guianan Lowland Humid Forest
Tropical Montane Humid Forest
Tropical High Montane Scrub & Grassland (Super-Paramo, Xeric and Moist Puna)
Tropical Andean Shrubland & Grassland (Yungas, Paramo, Puna, Bolivian-Tucuman)
Mediterranean & Southern Andean Cool Semi-Desert Scrub & Grassland
Tropical Andean Cool Semi-Desert Scrub & Grassland (Xeric Puna Succulent Scrub)
Brazilian-Parana Cliff, Scree & Rock Vegetation
Guianan Montane Cliff, Scree & Rock Vegetation
Tropical Andean Cliff, Scree & Rock Vegetation
Chaco Xeromorphic Cliff & Other Rock Vegetation
Interandean Xeromorphic Shrubland & Grassland
Xeromorphic Scrub & Woodland (Chaco, Colombian-Venezuelan)
Interandean Valley Xeromorphic Scrub & Woodland
Caatinga - Xeromorphic Scrub & Woodland
Chaco Xeromorphic Shrubland & Savanna
Atacama Semi-Desert Riparian Scrub (included Riparian)
Andean Cool Semi-Desert Saxiculous Vegetation
Tropical Seasonally Dry Forest
Brazilian-Parana Dry Forest (Cerrado, Caatinga, Paraná)
Colombian-Venezuelan Dry Forest (Tumbes Guayaquil and Llanos)
Central Guianan Seasonal Dry Forest
Tropical Andean Montane Dry Forest
Bolivian Tucuman Seasonal Dry Forest
Open Water
Amazonian Floodplain Forest
Amazonian Swamp Forest
Cerrado Floodplain Forest (Beni, Pantanal, Chaco)
Swamp Forest (Beni Chiquitano, Chaco)
Guianan Riparian Forest
Andean Riparian and Floodplain Forest
Andean Dry Valley Riparian Forest
Mangrove
Neotropical Freshwater Aquatic Vegetation
Amazonas Delta Peat Marsh
Guianan Bog & Fen
Chaco & Espinal Brackish Marsh
Tropical Atlantic Coastal Salt Marsh
Andean Montane Bog
Andean Altiplano Salt Flats
SPA.2021
Sources: modified from Comer et al 2020 (Vegetation classes); RAISG (reference boudaries; rivers; cities); WCS (Amazonia basin new classification)
Amazon basin
National border
National capital
Main cities

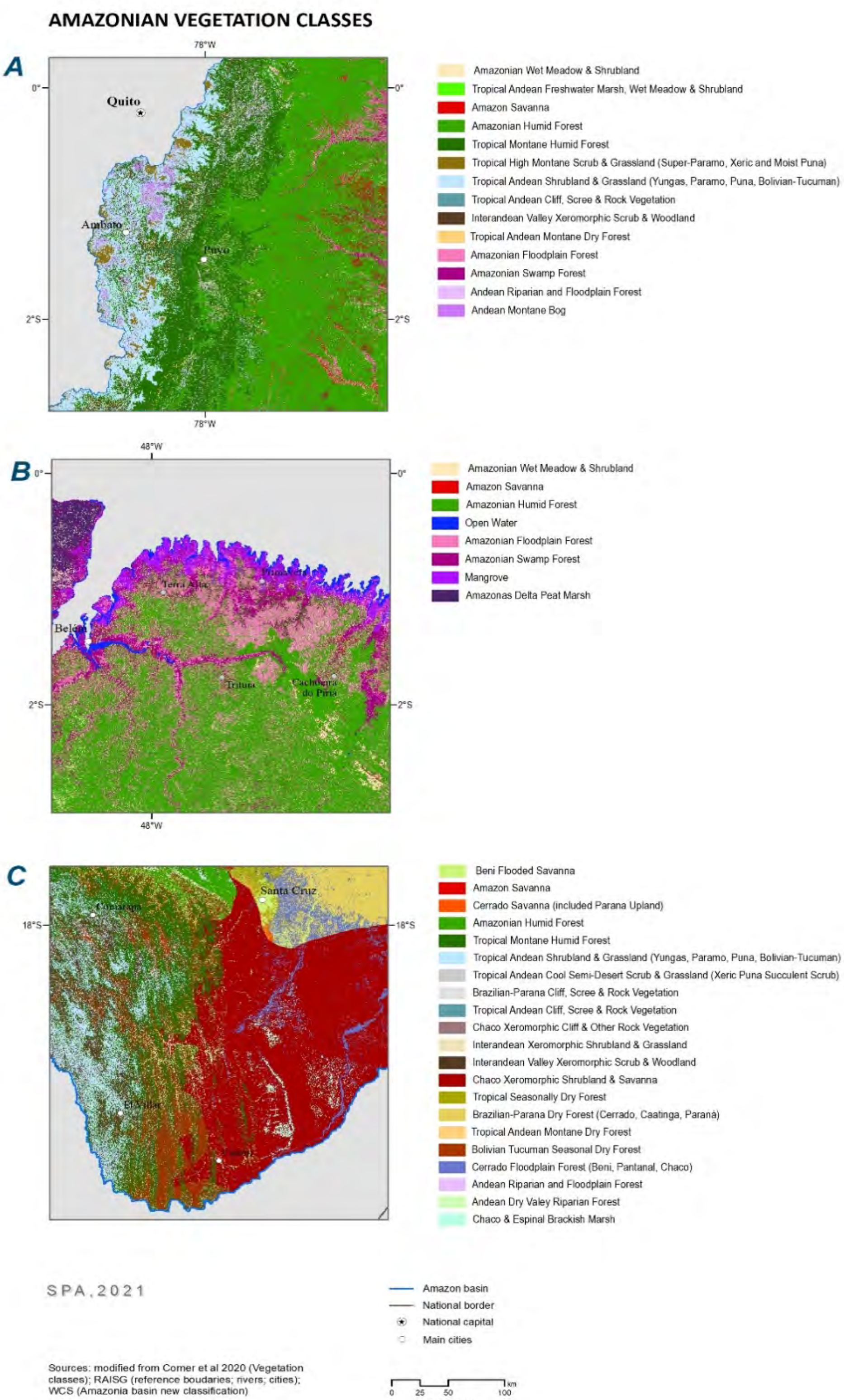


Figure 29.2 Amazonia's diverse array of ecosystems need to be considered when deciding how and where to restore. The vast extent of the Amazon means that many of these are only apparent when taking a closer look (boxes A-C). Sources: Comer et al (2020), RAISG (2020), and WCS – Venticinque et at (2016).

Crucially, restoration may support the integrity of the biome itself, enhancing its resilience to climate change by reducing the influence of climatic extremes and avoiding dangerous tipping points resulting from climate and land-use change (Chapter 23). This is because forest restoration could help the Amazon maintain its hydrological integrity, with evapotranspiration from restored forests contributing to the east-west transfer of moisture. This, in turn, could help support aquatic ecosystems, ensuring the maintenance of river discharge dynamics across the basin, and even the nutrient transfer from freshwater to floodplains and beyond. Restoring the basin's hydrological functioning could also help prevent forest fires, which are one of the main determinants of any sudden tipping point (Nobre *et al.* 2016). However, care must be taken to ensure that restoration itself does not make landscapes more flammable; for example, secondary forest understories tend to be hotter and drier in the day than primary forests (Ray *et al.* 2005), and, depending on what systems they replace, have the potential to aid the spread of fire across landscapes. Forest restoration will therefore require additional measures to reduce risks from fires.

29.2.4. Societal benefits

Restoration of forests and sustainable economic activities are a high priority for some of the most deforested regions of the Amazon, as these older deforestation frontiers include some municipalities with the lowest Human Development Index values (HDI) (Rodrigues *et al.* 2009). The transformation of unproductive lands into productive and sustainable agricultural or agroforestry systems could yield many direct economic and social benefits (Chapter 28), but there are also many indirect effects of restoration that could provide benefits for society beyond the producers. For example, the climatic benefits of increasing forest cover (e.g., Alkama and Cescatti, 2016) could mitigate some of the higher temperatures associated with climate change, thereby improving other economic activities across the landscape, and supporting well-being. Some of these benefits could be of considerable economic importance, as maintaining dry season length could enable the continuation of 'double cropping' systems which are vulnerable to climate change (e.g., Andrea *et al.* 2020). Landscape restoration could also be a very efficient tool for fire prevention and control, preventing the many negative social costs of fire (Chapter 19). The restoration of aquatic systems will not only improve access to clean water but could also support new fisheries.

Restoration could also have important political consequences, although these remain understudied, especially in developing countries (Blignaut *et al.* 2013). Many Amazonian countries have included restoration as part of their NDC commitment to the Paris Agreement, and several Amazonian countries (Peru, Bolivia, Ecuador, and Brazil) have made commitments for restoration through programs such as Initiative 20x20. Ecological restoration, like all political initiatives, needs to be placed within the context of policies and the inherent tradeoffs between competing objectives (e.g., Baker and Eckerberg 2013). Within this context, governance and institutional frameworks become significant (Mansourian, 2017). Viewed from such a perspective, negotiations can then develop around what types of restoration projects are to be implemented and where, and who manages the land afterwards (see Chazdon *et al.* 2020; Mansourian, 2021). Restoration is likely to be important in this context as it influences many aspects of well-being targeted by political decision makers; these include the products harvested from restored ecosystems, health benefits such as water quality or changes in exposure to air pollution or high temperatures, reduced exposure to natural disasters such as flooding, or improvements in well-being from increased access to natural systems.

Restoring landscapes also generates additional value such as soil and water protection, microclimate regulation, and provision of goods. This change in political and economic value of the landscape may generate new interests, which could potentially shift the balance of power, impacting conflicts and the use of natural resources, as well as improving inequalities and land tenure rights (Mansourian, 2016; Ding *et al.* 2017). Expanding restoration beyond the site or project level to the landscape scale inevitably involves more stakeholders and adds further complexity to governance. Overcoming this will require identifying new institutional domains for stakeholders to meet, negotiate, and co-create the necessary conditions for restoration (van Oosten *et al.* 2021). Achieving it helps ensure that governments uphold important constitutional responsibilities related to environmental protection and accessibility (see the Atrato River legal case in Colombia). Incorporating these benefits into political decision-making could help garner support for the implementation of restoration across the basin.

29.3. Landscape and catchment approaches to restoration and conservation

Once a region has been identified as a priority for restoration, landscape and catchment approaches can help ensure that restoration actions are effective and deliver the greatest benefits to the broadest range of stakeholders.

Within the region of interest, landscape approaches aim to "*provide tools and concepts for allocating and managing land to achieve social, economic, and environmental objectives in areas where agriculture, mining, and other productive land uses compete with environmental and biodiversity goal*" (Sayer *et al.* 2013). They have been redefined as "*integrated landscape approaches*," reflecting the need to reconcile multiple and conflicting land-use claims and help establish multi-functional landscapes (Reed *et al.* 2016a). The term now encompasses a wide-range of approaches (Reed *et al.* 2016), including aquatic approaches such as integrated watershed management (e.g. Shiferaw *et al.* 2008). Restoration specific approaches include Forest Landscape Restoration (Ianni, 2010) which is now promoted by many leading environmental NGOs and international institutions such as FAO, or initiatives such as the Bonn Challenge (Mansourian and Vallauri, 2005; Lamb *et al.* 2012; Maginnis and Jackson, 2012). According to FAO, the Forest and Landscape Restoration Mechanism (FLRM) aims to "*restore degraded landscapes by identifying and implementing practices that restore a balance of the ecological, social and economic benefits of forests and trees within a broader pattern of land uses*". The broad approach of the FLRM enables decision makers to consider all components of a landscape, from agriculture to restoration and forestry, and support long-term sustainability decisions through economic zoning (Celentano *et al.* 2017). They also call for a consideration of all ecosystems within a region, supporting restoration that goes beyond *terra firme* forests, to include restoration of other systems like savanna enclaves and flooded forests (Chazdon *et al.* 2020b; Ota *et al.* 2020; César *et al.* 2021). What these all recognize is that considering where and how to restore at the catchment or landscape scale can help return much higher benefits than simple site-based approaches. We outline some of the key benefits of planning Amazonian restoration within landscapes and catchments below.

29.3.1. Integrating aquatic and terrestrial systems

Terrestrial and aquatic systems are often considered separately but are inextricably linked. Moreover, considering them together can provide large benefits for aquatic biodiversity at no cost to terrestrial biodiversity (Leal *et al.* 2020). It has long been established that riparian zones can act as buffers for sediment and nutrient retention (Peterjohn and Correll, 1984; Allan, 2004; Saad *et al.* 2018; Luke *et al.* 2019), can moderate extremes in stream water temperatures (Macedo *et al.* 2013a), and are important for biodiversity in both streams and floodplain systems (Arantes *et al.* 2019; Dala-Corte *et al.* 2020). For example, in southeast Brazil, modeling efforts using InVEST have explored different riparian restoration strategies that can reduce soil loss and river sediment export by filtering sediments before they reach streams (Saad *et al.* 2018). Even in highly modified agricultural landscapes, the condition of riparian zones can strongly influence stream water quality via nutrient retention. For example, research in the

Amazon-Cerrado frontier in the Brazilian state of Mato Grosso highlights the capacity of functionally-diverse riparian vegetation to capture and sequester nutrients (Nóbrega *et al.* 2020). Concentrations of nutrients (organic carbon, total nitrogen, phosphorus, calcium, and potassium) in overland flow from croplands are substantially greater than from nearby riparian gallery forest. Moreover, soils from intact gallery forest, especially those with biodiverse plant assemblages with varied root systems, display properties that better enable nutrient uptake, as well as the degradation of nutrients and pollutants as compounds travel through hyporheic zones. Terrestrial systems can also affect stream temperature; a study of 12 catchments in the upper Xingu watershed reported warmer water temperatures in streams from pasture and soya-dominated catchments, with daily maxima 3-4°C higher than in forested catchments (Macedo *et al.* 2013b). Collectively, these studies provide rationale for placing a premium on gallery forest and riparian zone restoration to mitigate land-use change's impacts on sediment export, water chemistry, and thermal regimes.

Source water protection involves a suite of management practices to protect water quality and quantity, especially in the context of water supplies for urban areas (Abell *et al.* 2019). When coupled with strategic land protection in targeted catchments, restoration can play a key role in source water protection, via activities such as forest restoration, riparian restoration, livestock exclusion, and wetland restoration. Source water protection is an actively promoted restoration strategy in parts of the Amazonian Andes to improve water quality and preserve biodiversity (Bottazzi *et al.* 2018). In the Bolivian Andes, a payment for ecosystem services effort known as *Watershared* pays farmers and cattle owners to prevent forest conversion and exclude livestock from riparian forest, all predicated on the notion that improving the condition of riparian zones translates into tangible outcomes for water quality and quantity. Contamination of drinking water by the bacterium *E. coli* is of particular concern where livestock graze freely in streams. Fencing has been shown to be a successful strategy for reducing per capita human cases of diarrhea by preventing livestock intrusion (Abell *et al.* 2017). Similar practices of livestock removal coupled with riparian revegetation have been implemented elsewhere in the highlands of the tropical Andes to improve water quality and supply for urban areas (Goldman *et al.* 2010; Higgins and Zimmerling, 2013). *Paramo* and wetland restoration is also a key priority in the Andes given the benefits for water quality and flow regulation (Buytaert *et al.* 2006; Ochoa-Tocachi *et al.* 2016) and carbon emissions (Schneider *et al.* 2020).

In addition to water quality, land use modifies the magnitude and variability of river flows. Although studies have evaluated changes in river discharge due to deforestation and the conversion of land to intensive agriculture in Amazon catchments (Hayhoe *et al.* 2011; Davidson *et al.* 2012; Dias *et al.* 2015; Farinosi *et al.* 2019), there have been few attempts to track stream flow responses to terrestrial restoration and afforestation. A systematic review of more than 300 case studies worldwide examining impacts of forest restoration on stream flows revealed a deficit of information from the humid tropics (Filoso *et al.* 2017). However, the studies that do exist from the tropics suggest forest restoration can be beneficial. For example, a study in Madagascar shows how forest restoration can reduce erosion and flooding related to overland flow (van Meerveld *et al.* 2021). In a study in the Philippines, forest restoration increased infiltration enough to offset reductions in water balance from additional evapotranspiration, leading to a net positive water balance that could help maintain dry season streamflows (Zhang *et al.* 2019). In an experimental study of hydrological response to land use and afforestation in the Ecuadorian *páramo* highlands, water balance and flow duration curves were compared among four small headwater catchments (Buytaert *et al.* 2007), including one afforested with pine (*Pinus patula*), a catchment with intensive livestock grazing and potato cultivation, and two catchments with intact *páramo* vegetation. Flow regimes were dramatically modified in the afforested catchment, with severe reductions in base and peak flows. Although the cultivated catchment also displayed altered flows, they were less drastic than observed in the catchment with planted pines. These results suggest that in the Andean highlands, afforestation by non-native tree species used to reduce hillside erosion could result in significant decreases in base flows and compromise water supply. Finally, although untested, it seems plausible that forest restoration could support streamflow if it reduces landscape temperatures and increases rainfall (see Section 29.3.3).

29.3.2. Improving landscape and catchment connectivity for biodiversity

Island biogeography theory has underpinned the discipline of landscape ecology, guiding much of the theoretical and empirical evidence on the outcomes of habitat fragmentation. There are long-running debates about the relative importance of habitat extent versus habitat fragmentation (or changes in landscape configuration without changing habitat extent) (e.g., Fletcher *et al.* 2018; Fahrig *et al.* 2019), but a growing consensus recognizes that while habitat extent is the most crucial factor, configuration also matters for species across the world (Arroyo-Rodríguez *et al.* 2020). Crucially, a global assessment of species' responses to anthropogenic edges suggests that tropical species are inherently more sensitive to fragmentation than temperate species (Betts *et al.* 2019). For example, many Neotropical understory birds have a limited capacity to fly more than a few tens of meters (Moore *et al.* 2008) and are reluctant to cross even small roads (Lees and Peres, 2009), making them highly susceptible to human activities that fragment habitat into discrete patches (Ferraz *et al.* 2003; Lees and Peres, 2006). Low dispersal ability is evident over evolutionary time scales, as rivers have played a major role in determining the evolution of the Amazon's terrestrial diversity (Chapter 3). Freshwater species are also susceptible to changes in connectivity (Hurd *et al.* 2016), and the Amazon's migratory catfish have the most spatially expansive metapopulations of freshwater fish across the world (Hurd *et al.* 2016).

Given the high sensitivity of many Amazonian species to habitat fragmentation, restoration will be most effective if is deployed in a way that both increases habitat *and* maintains or enhances connectivity between remnant forest patches or rivers to ensure migration can take place and gene flow is permitted between populations. Mixed suites of restoration strategies can help improve connectivity between higher quality patches. For example, forest restoration efforts can create corridors that encourage movement between the last remaining habitat patches and have proven successful at increasing population size and reducing threat status for species such as the black lion tamarin (*Leontopithecus chrysopygus*) in the Atlantic Forest. Similar approaches would support conservation efforts for some of the Critically Endangered species in the most deforested regions of the Amazon (Figure 29.1), including in the Maranhão-Pará border (Figure 29.1), Rondônia, and the Andean regions. However, enhancing connectivity in these regions will only be effective if carried out in conjunction with complementary conservation measures that protect the last remaining populations and habitats for these species (Chapter 27).

For some species, connectivity can be enhanced without physically connecting disjunct patches. For example, high quality habitat will be functionally connected if species are able to cross the non-habitat "matrix" in between (e.g., Lees and Peres, 2009). The permeability of an agricultural matrix composed of cattle pastures and mechanized agriculture is normally very low, but is likely to be enhanced by restoration that encourages occasional trees (e.g., Rossi *et al.* 2016), plantations (Barlow *et al.* 2007), or more diverse stands used in agroforestry (Zanetti *et al.* 2019). Connectivity across the landscape – and benefits for aquatic systems – could also be enhanced by restoring a full network of riparian vegetation (Rossi, Jacques Garcia Alain Roques, and Rousselet, 2016; Kremen and Merenlender, 2018).

29.3.3. Local climate benefits

Forest cover influences Amazonian climates by reducing regional temperatures and maintaining rainfall (see Chapter 6). Restoration in deforested regions could therefore provide important benefits for local and regional climate (Mendes and Prevedello, 2020). For example, studies across the world show that forest restoration can help reduce the urban heat island effect if conducted around cities (Bhagwat *et al.* 2008), and can reduce the occurrence of excessive stream temperatures (Hall *et al.* 2020). There is also some evidence that the configuration of forest cover in a landscape could influence climatic benefits of restoration, with more fragmented patterns actually increasing rainfall and maximizing reductions in land surface temperature (Mendes and Prevedello, 2020). However, there is uncertainty about how this occurs at scale; one modelling study suggests that rainfall increases on agricultural land and decreases on the forests themselves (Garcia-Carreras and Parker, 2011), which could increase forest flammability and enhance drought sensitivity. Furthermore, while a fragmented configuration may reduce the temperature of the deforested area, it is also likely to increase understory temperatures in the remaining forests, contributing to faster drying and increasing flammability. The local climatic benefits of restoring forests in a particular configuration is important but requires further research.

29.3.4. Reducing the risk of socio-environmental disasters

Landscape or catchment level restoration can reduce the risk of events that are detrimental to the Amazon's people and nature. Forest fires are a growing threat to the Amazon (see Chapter 24), and, unlike deforestation and agricultural fires, benefit almost no-one (Barlow *et al.* 2020). It is possible that targeted restoration could help reduce the occurrence of these forest fires by influencing landscape temperature and humidity (see Section 2.3), which in turn would make fuels on the forest floor less flammable by increasing humidity and reducing temperatures. Restoration could also be used to 'buffer' primary forest edges; although we are not aware of any research into this, we believe such restored forest buffers could have two complementary roles. First, primary forest edges are drier and hotter than forest interiors, which contributes to them being frequently degraded by fire incursion (Silva Junior *et al.*2020); the restoration of closed canopy vegetation alongside primary forests would help buffer those forests edges from the hot microclimate of the agricultural matrix, making them less flammable, and could also help suppress pyrophytic grasses that help spread fires. Second, restoration alongside primary forests would help isolate those forests from the wider landscapes where ignition sources are most prevalent. While the use of 'green firebreaks' remains untested in an Amazonian context, the 'Green Hug' project (*Abraço Verde*) in the Atlantic Forest provides insight into the long-term viability of projects using agroforestry buffers to project forest edges (Chazdon *et al.* 2020a). Research is needed to evaluate the effectiveness of green firebreaks in the Amazon, including understanding the ideal widths and what active restoration measures (tree planting or enrichment) are required to maximize other benefits (e.g., economic returns). It will also be important to minimize risks from the restored areas, as secondary forests could themselves become 'wicks,' helping conduct fire across the landscape (e.g., Ray *et al.* 2005).

Catchment-scale restoration can also help mitigate the risk of flooding, which is exacerbated by deforestation (Bradshaw *et al.* 2007). Evidence from China suggest broadleaf trees are especially effective (Tembata *et al.* 2020), casting doubt on the flood mitigation value of oil palm or other species that are planted at low densities. Models suggest that sub-catchment restoration of riparian forests is likely to be one of the most effective mechanisms to reduce flooding, with restoration across 10-15% of the catchment reducing the peak magnitude of flooding by 6% after 25 years (Dixon *et al.* 2016).

28.3.5. Meeting multiple aims and optimizing benefits

Although win-win outcomes are rare in conservation and development (e.g., Muradian *et al.* 2013), trade-offs can be minimized and multiple benefits are more likely to be realized by implementing changes at the landscape or catchment scale (Reed *et al.* 2016b) . Going beyond site-specific management and planning at the landscape or catchment level allows restoration to use optimization techniques to quantify trade-offs or complementarity between various restoration targets. Such approaches are helping prioritize restoration across the world (Strassburg *et al.* 2020), and could allow restoration actions to achieve a broader range of benefits whilst minimizing losses (Stanturf *et al.* 2015). For example, although biodiversity and carbon are positively associated in human-modified Amazonian forests, this relationship dissipates in undisturbed primary forests where turnover in species composition is high (Ferreira *et al.* 2018). Considering this turnover in biodiversity in planning provides a way to deliver large gains for biodiversity conservation with very minor reductions in carbon storage (Ferreira *et al.* 2018).

With so many potential co-benefits of restoration, it is vital that these are considered as part of an integrated planning process with full consideration of landscape and catchment processes (Reed *et al.* 2019). For example, peri-urban restoration aimed at providing climatic benefits for cities could also provide important social benefits, such as for recreation or local consumption, if the species provide fruits or other products. Similarly, restoration aimed at terrestrial conservation could also support aquatic biodiversity, without any cost to terrestrial conservation objectives (Leal *et al.* 2020).

Planning beyond specific sites also allows restoration to consider and compare the relative benefits of a full suite of interventions, helping ensure efforts are invested in the most effective measures. For example, landscape-scale planning is essential to decide when and where to adopt active or passive restoration of secondary forests, or whether strategies should target reforestation or focus on alternative measures such as avoiding degradation of existing forests or economic recovery in degraded lands. For example, it is likely that avoiding degradation in existing forests can be a cost-effective approach to conserving carbon and biodiversity when compared to active or passive restoration of forests on farmland.

29.4. Encouraging a broader forest transition

Forest loss and gain across the Amazon can be seen in terms of a forest cover transition. The term forest transition, introduced by Mather (1992), refers to a change in forest cover (shrinkage or expansion) over a given area (landscape, regional, national level) and time period. This process typically shows three main periods. First comes a phase of intensive deforestation due to forest conversion into agricultural lands and pastures, followed by a net gain of forest area through reforestation and restoration actions as well as passive natural regeneration. The third and last phase is a stabilization phase with a constant forest cover area. Europe, North America, and recently some tropical countries have already gone through their forest transition and are now witnessing sustained increases in forest cover (Mather, 1992; Meyfroidt and Lambin, 2010).

In most countries where a forest transition has occurred, the new forests are very different in structure, composition, and function. While generalist species can benefit, these new forests are unlikely to provide additional habitat for specialist species restricted to old-growth systems (Wilson *et al.* 2017; Lees *et al.* 2020). Moreover, evaluations of forest transitions require an understanding of global trade and leakage. Improved environmental performance and expanded forest cover in more developed countries may have come at the cost of environmental destruction elsewhere, typically in the Global South (Lees *et al.* 2020). This leakage can also occur within regions and ecosystems; within the Amazonian context, care needs to be taken to ensure conservation and restoration activities in one area do not simply push social and environmental pressures elsewhere, including from one region of the Amazon to another, or from the Amazon to other ecosystems (e.g., de Waroux *et al.* 2016) such as the Cerrado (Carvalho *et al.* 2019).

While net gains in forest cover may occur over time in the Amazon, there is no evidence to suggest they have already begun, and the most deforested regions of the basin have failed to see an increase in forest cover since 1997 (Smith *et al.* 2021). However, actions that avoid loss and stimulate gain are critical for the basin as a whole; the Amazon forest generates approximately one third of its own rainfall (Staal *et al.* 2018) (see Chapters 6 and 22), and excessive deforestation could have huge environmental consequences, particularly on precipitation regimes and consequently on the capacity of the remaining forest to survive (Nobre *et al.* 1991; Oyama and Nobre, 2003; Hutyra *et al.* 2005; Sampaio *et al.* 2007a), with tipping point estimates ranging from 20-25% (Lovejoy and Nobre, 2018) to 40% deforestation (Sampaio *et al.* 2007b) (see Chapter 24). Furthermore, if deforestation goes beyond these estimated thresholds, forest regeneration itself could also be hampered by unfavorable climatic conditions (e.g., Elias *et al.* 2020).

Given this context, how can restoration mitigate the loss stage of the Amazon's Forest transition? One way that restoration could help is if it was partly oriented towards timber production, which could relieve pressure on natural forests, still the main provider of timber in the region. During the last 50 years of recent colonization of the Amazon, natural forests have been selectively logged, with 108 Mha of forest (20% of the total forest area) exploited for timber production (Food and Agriculture Organization of the United Nations and International Tropical Timber Organization, 2011).

There are many reasons why it would be beneficial to replace timber production from natural forests with timber plantations on deforested areas. First, although sustainable forest management practices are considered a potential tool for Amazonian Forest conservation (Putz *et al.* 2008; Edwards *et al.* 2014) and provide income and employment (Putz *et al.* 2012), natural timber production itself is unsustainable under present-day conditions of logging intensities and rotation cycle duration (Sist *et al.* 2021). In the Amazon, selective logging regulations typically set a rotation cycle of 20 to 35 years with a logging intensity varying from 15 to 30 m^3/ha (Sist *et al.* 2021). Several studies show that under such extraction regimes, less than 50% of the timber extracted can recover (Schulze, 2003; Sist and Ferreira, 2007; Putz *et al.* 2012). A recent study simulating timber recovery in the region confirmed this result and showed that even under a long rotation length of 65 years and a logging intensity of 20 m^3/ha, the timber recovery would be only 70% (Piponiot *et al.* 2019a). This means that under the present logging regulations natural Amazonian forests alone will not be able to supply the timber market demand in the long term (i.e., during the second rotation, 30 years from now). Second, timber in natural forests generates low profits when carried out using best practices (Putz *et al.* 2008). Third, while it is much better than non-forest land uses for conservation and carbon storage, most logging practices in the Amazon continue to be illegal (Brancalion *et al.* 2018) and generate high damage to the stand. Such practices also open up forests, make them more accessible to hunters (Peres, 2001) and vulnerable to forest fires (Holdsworth and Uhl, 1997). Finally, illegal logging also undermines the financial profitability of improved tropical forest management.

If restoration met some of the demand for timber, it could decrease the pressure on natural forests, allowing larger areas to be set aside for conservation and lower-intensity management of production areas. It would also allow timber from natural forests to be targeted to niche rather than mass markets, with higher prices enabling reduced offtake rates and longer reharvest intervals. This new market for timber extracted from natural forests should take into account the specific wood properties of old natural timber, the costs of sustainable forest management practices, and the social and environmental services provided by well-managed natural forests. Selective logging could be sustainable if it adopted much longer cutting cycles (65 years), reduced logging intensities (10 m^3/ha instead of 20 m^3/ha) and prevented incidental damage to the stand through reduced-impact techniques (Piponiot *et al.* 2019b; Sist *et al.* 2021). Additional sources of timber, such as plantations of exotic or native species, enriched secondary or degraded forests, integrated crop-livestock-forestry systems, and other agroforestry systems could be implemented within forest restoration programs under the Bonn initiative (Lamb *et al.* 2005). The rising interest in tropical forest restoration, crystallized by the Bonn challenge in 2011, is a unique opportunity to initiate this forest transition by encouraging restoration with economically-viable timber plantations in deforested areas and promoting the management of secondary forests on abandoned agriculture lands (Ngo Bieng *et al.* 2021). However, the success of any forest transition program depends primarily on forest law enforcement addressing illegal logging and promoting sustainable silvicultural practices.

The theory of forest transition focuses on the terrestrial part of a landscape, but what would an aquatic transition look like? Within the Amazon, avoiding the worst outcomes for aquatic systems will require preventing the most damaging new dams from being built, preventing land-use change, and regulating the use of harmful agrochemicals – all of which could be supported by alternative energy sources, novel bioeconomies, and the encouragement of better agricultural practices (see Chapter 20). Within the aquatic zone itself, overfishing might be mitigated by implementing, encouraging, and strengthening co-management systems over large regions (see Chapters 20, 28 and 30). Improving the status of fish populations would also benefit floodplain systems, as some of the species that have been declining with harvesting pressure, such as tambaqui *Colossoma macropomum* (Tregidgo *et al.* 2017), provide important ecosystem processes (Costa-Pereira *et al.* 2018). Aquaculture could also play an important role, but many issues require further analysis and investigation. For example, will supplying farmed fish relieve pressure on wild fish stocks? Can the many risks of aquaculture (increased nutrient loads, risks of species introduction, increased demand on natural fish populations or crops as food sources for produced fish) be managed properly? If they can, then aquaculture could also reduce demand for protein that requires orders of magnitude more land per kilo of protein, such as beef, even when inputs are considered (Piva Da Silva, 2017).

29.5. Ensuring broader societal benefits from restoration

Restoration exists within a social context, and therefore produces environmental conditions that must not only be ecologically sound but also economically feasible and socially acceptable.

A recent study showed that nearly 300 million people in the tropics live on lands suitable for forest restoration, and about a billion people live within 8 kilometers of such lands (Erbaugh *et al.* 2020). Many of these people live in poverty. Restoration is therefore likely to occur within vulnerable social contexts and must be socially and economically acceptable as well as maximize its potential to include local populations and improve local livelihoods over the long term (Palmer *et al.* 2005; Reed, 2008; Lee and Hancock, 2011; Erbaugh *et al.* 2020). It can achieve this by engaging a diverse range of stakeholders from the public, private, and civil society sectors, and building and sustaining such coalitions of support. When carried out in a participatory way, restoration has the potential to increase well-being and improve livelihoods through the sale of forest products, increase food supplies, improve water security, and support the diverse cultural values people place on landscapes (Aronson and Alexander, 2013; Sabogal *et al.* 2015; Brancalion and Chazdon, 2017; Stanturf *et al.* 2019). In most cases this requires thinking beyond the individual site being restored and taking into account the broader benefits at the landscape scale: it is well documented that the success of forest and landscape restoration requires the empowerment and capacity building of local communities and their engagement in decision-making processes.

Land tenure has a strong influence on the likelihood, feasibility, and success of restoration efforts. Conflicting tenure regimes and property rights may complicate restoration, especially if there are multiple landowners (de Jong *et al.* 2018), while tenure insecurity has been cited as a disincentive to invest in restoration (Fortmann and Bruce, 1991; Cotula and Mayers, 2009). Equally, landscape restoration may in turn affect tenure and land rights for many local and Indigenous communities and landowners, as returning vegetation to the land may entitle them to legal tenure. It may also increase family incomes, employment opportunities, and community resilience (Adams *et al.* 2016; Erbaugh and Oldekop, 2018). For example, one reforestation scheme within the Brazilian Atlantic Forest has created over 200 jobs related to native seed collection, seedling production, planting, maintenance, and downstream manufacturing of timber and non-timber products (Calmon *et al.* 2011).

Regaining land tenure and authority over restored lands also has health benefits for many marginalized and Indigenous peoples. Well-being encompasses much more than economic solvency; indicators of health include material (food, water, shelter, security), social (identity, belonging, self-esteem), and spiritual/cultural benefits (related to sacred places, totemic animals and artefacts, beliefs, customs, and languages) (Verschuuren, Subramanian, & Hiemstra *et al.* 2014). Additionally, pollution often affects people's health, and restoration efforts need to consider a broad approach that includes physical and mental well-being. This is particularly relevant for oil and mining pollution, which have had direct effects on Indigenous and marginalized communities in the Amazon (see Chapter 20). It is vital that the full social and ecological costs of mining are factored into decisions about where and when it takes place.

Restoring degraded landscapes also offers a means to rebuild communities and decentralize governmental institutions. For instance, about 6,000 Indigenous people residing in the Xingu Indigenous Park in Brazil, along with other communities inhabiting the heart of the basin downstream of extractive reserves of the Terra do Meio, have been negatively affected by changes in the quantity and quality of water that enters their lands (Schwartzman *et al.* 2013). The restoration of 50 km^2 of riparian forests in the Xingu River Headwaters (Schmidt *et al.* 2019) has helped reduce run-off from crops and pastures that were contaminating water bodies (Schiesari *et al.* 2013).

29.6. The climate resilience of restoration options

Restoring ecosystems in the context of climate change requires understanding when it is best to rebuild past ecosystems, and when it is better to attempt to build resilient ecosystems for the future (Harris *et al.* 2006). Determining where historical baseline targets are viable and where alternative targets must be considered is site-dependent and associated with projected changes (Jackson and Hobbs, 2009). We consider these issues in terrestrial and aquatic systems.

29.6.1. Climate resilience of terrestrial restoration

A growing set of evidence reveals how the Amazon's primary forests are being affected by climate change and climatic extremes, including increased mortality of individual trees (Phillips *et al.* 2009; McDowell *et al.* 2018) and changes in species composition (Esquivel-Muelbert *et al.* 2019) (see Chapter 24). Studies also show strong associations between tree mortality and climatic changes such as increased intensity and duration of the dry season (Aleixo *et al.* 2019a; Adams *et al.* 2017) and warmer temperatures (Sullivan *et al.* 2020; Allen *et al.* 2010). But what about the sensitivity of secondary forests? Here we outline five lines of evidence suggesting they may be particularly sensitive to climatic change.

The first is spatial; secondary forests may be especially vulnerable to ongoing climate change as they are mostly situated in the drier and more seasonal

Box 29.1: The Xingu Seed Network as a social-ecological collaboration

To reduce restoration costs, the Xingu Seed Network undertook collective action involving private landowners and local and Indigenous communities (Sanches, Futemma & Alves, 2021; Urzedo *et al*., 2016; Schmidt *et al*., 2019). This is important as many governmental officials do not always appreciate the full extent of the importance of landscapes to local and Indigenous communities in terms of food security, income, nutrition, employment, energy sources, and well-being. The principle of social involvement in restoration led to the creation of the Xingu Seed Network, involving seed collection using traditional knowledge and promoting a forest economy by generating income. This initiative involved over 450 seed collectors from 16 municipalities of Mato Grosso state (Brazil), distributed in 20 Indigenous villages and 14 agrarian reform settlements, with at least 5,000 ha under restoration, involving more than 300 landowners, and generating US $380,000 (Durigan *et al.* 2013; Urzedo *et al*., 2016; Schmidt *et al*., 2019). By restoring degraded landscapes, it provides new opportunities to build relationships between private landowners and communities, and/or between communities and governments, based on collaboration rather than confrontation. While such progress is often slow at the landscape level, partly due to entrenched attitudes in bureaucracy, it offers significant potential shifts in attitudes and working relationships that can lead to evolution in socioecological policies.

parts of the Amazon where deforestation has predominated (Smith et al; 2020). The second is physiological; secondary forests are dominated by fast-growing trees with low wood densities (Berenguer *et al.* 2018; Poorter et al. 2019) or have large thin leaves that do not conserve water, and these may be especially vulnerable to drought by cavitation or carbon starvation (Phillips *et al.* 2009; McDowell *et al.* 2018; Aleixo *et al.* 2019b). The third line of evidence is empirical; secondary forests monitored over time have significantly lower rates of carbon accumulation during drier periods (Elias *et al.* 2020). This is in part driven by mortality: several studies in primary and secondary forests recorded higher tree mortality after global extreme climatic events associated with El Niño/La Niña Atlantic oscillation (NAO) in the Amazon in 2005 and 2016 (Chazdon *et al.* 2005; Leitold *et al.* 2018). However, in secondary forests is also driven by reduced growth (Elias *et al.* 2020). The fourth reason relates to their structure and microclimate; low canopies and high rates of stem turnover in secondary forests mean they have higher understory temperatures and lower humidity levels (Ray *et al.* 2005), making them more vulnerable to extreme climate conditions as well as fire events (Uriarte *et al.* 2016). Finally, while many primary forest trees have a deep rooting depth (Nepstad et al. 1994), this seems less likely in secondary forests, where average stem sizes are much lower. It is notable that seedlings are vulnerable to drought in disturbed forests in Borneo, and that these droughts also push the community composition back towards ruderal pioneers (Qie *et al.* 2019).

Heightened sensitivity to climate change could be offset if existing gradients in dry season intensity and rainfall drive adaptation towards greater drought or heat sensitivity. Primary forests are changing their species composition in response to climate change (Esquivel-Muelbert *et al.* 2018); the fast turnover and high dispersal capacity of pioneer species may facilitate these changes in secondary forests, especially when they are functionally connected to a large species pool of potential colonists. It is therefore possible that more drought-resilient secondary forests could emerge in the future. These may resemble the species composition and successional trajectories found in regenerating tropical dry forests, where the initial stages of forest succession are dominated by species with drought tolerant traits (e.g., (Lohbeck *et al.* 2013). Where forests are unable to change naturally, or where a faster rate of change is desired, then enrichment planting could help encourage species with traits that are better adapted to heat stress or longer dry seasons. The cutting of climbers and liberation thinning could provide additional support (Philipson *et al.* 2020), although evidence from Borneo suggests that the benefits of liana cutting may be reduced during extreme droughts (O'Brien *et al.* 2019). Finally, restoration at the landscape scale could help restoration efforts by maintaining a cooler and more humid regional climate (see Section 29.2.3).

Drought is not the only threat to forest restoration. Aleixo *et al.* (2019) showed that trees died more often during wet months than in drought years, and rain and storms that occur during the transition from dry to wet seasons in the Amazon might be the main cause of tree mortality during the wettest months (Negrón-Juárez *et al.* 2010). Forest restoration is also highly susceptible to fire, which can arrest successional processes in *terra firme* (e.g., Berenguer *et al.* 2018; Heinrich *et al.* 2021) and flooded forests (Flores *et al.* 2017). Forest restoration activities need to be aligned with actions that reduce landscape flammability, improve fire detection and combat, and support farmers in controlling ignition sources.

29.6.2. Climate resilience of aquatic restoration

Hydrological effects of climate change are likely to have a greater impact in the Amazon than in other regions of South America (Brêda *et al.* 2020). Notably, the impacts of climate change on aquatic systems can be exacerbated by land use change. For example, coupled climatic and hydrological models forced under contrasting deforestation scenarios suggest that precipitation outcomes shift from mean positive to mean negative in response to deforestation (Lima *et al.* 2014). In addition, deforestation can increase the duration of dry seasons and amplify seasonal variation in discharge. Importantly, water balance changes are not confined to deforested sub-basins, as atmospheric circulation spreads the effects basinwide (Coe *et al.* 2009).

Changes in water balance associated with climate change and deforestation will likely affect floodplain and river ecosystems in many ways (see Chapter 23). Decreased mean annual rainfall (Brêda *et al.* 2020) combined with increased frequency of extreme weather events in the Amazon (Marengo, 2009) will change seasonal inundation patterns, impacting species composition and biogeochemical cycling in Amazonian freshwater landscapes. Reduced inundation length can alter the selection for flood-tolerant species and ultimately the composition of floodplain forests; moreover, because floodplain trees generally lack traits linked to fire and drought resistance, they will be highly sensitive to any changes in the frequency, extent, or severity of fires (Flores *et al.* 2017). In rivers, precipitation and discharge regimes regulate sediment transport and aquatic nutrient dynamics (Devol *et al.* 1995; Almeida *et al.* 2015), and flood extent governs the input and processing of vast quantities of organic matter produced in terrestrial and seasonally flooded ecosystems that is further outgassed as carbon gas (Abril *et al.* 2014; Almeida *et al.* 2017). In the biological realm, altered seasonality in flood regimes could affect plankton community interactions, with potentially cascading food web effects (Feitosa *et al.* 2019). Thus, in addition to understanding site-level conditions prior to disturbance, effective restoration of Amazonian aquatic ecosystems should be attentive to watershed-scale hydrological, biological, and chemical alterations brought about by climate change.

29.7. Achieving meaningful restoration at scale

Restoration science has developed rapidly over recent decades, and while some knowledge gaps remain in the tropics, it has reached a point where it can provide clear evidence-based guidance to support restoration actions in a wide range of contexts (Chapter 28) and across whole biomes and landscapes. But restoration cannot happen in isolation; we have outlined how it must be linked to a broader suite of conservation measures that avoid further loss (Chapter 27). Crucially, research has shown that restoration needs to be integrated within society and the political context, and evidence can inform how to implement restoration in a way that is inclusive of all people in a landscape (while recognizing that not all stakeholders will necessarily benefit) (Reed *et al.* 2018). But how can this knowledge be used effectively? Here we examine the policy levers and incentives that can support the large-scale restoration that is required to mitigate climate change, avoid dangerous tipping points, reduce pressure on primary forests, support local livelihoods, and develop a thriving and flourishing Amazonian bioeconomy.

29.7.1. Enforcement and Monitoring

Many have experimented with technological and organizational solutions to restore environmentally-sensitive and sustainable economic production (e.g. Brondizio *et al.* 2021). Yet, these potential solutions will not be replicated or adopted at scale as long as the negative externalities of exploiting the forest's natural capital go unaccounted for. For example, the low market prices of illegal timber undermines the value of legal timber (Brancalion *et al.* 2018), making it much more challenging for companies that follow legal or certified practices to fund the monitoring and enforcement required to ensure post-harvest forest integrity across expansive and remote concessions (see Chapters 14, 19, and 27). Countering this requires changes in policy and governance (laws, taxes, subsidies) to make activities such as illegal logging economically unattractive. Green investment in land and landscape restoration requires efficient tools to monitor and verify environmental performance at plot, farm, landscape, and catchment levels. Monitoring and enforcement is also key to avoiding perverse effects of economic restoration, where technologies and policies promoting greater agricultural or silvicultural productivity paradoxically lead to increased deforestation (Garrett *et al.* 2018), or where large-scale ecological restoration causes "leakage" of environmental harm (e.g. Alix-Garcia and Gibbs, 2017).

29.7.2. Incentive-based measures

Restoration can be incentivized by carbon and/or biodiversity offsetting, payments for ecosystem services (PES) such as REDD+, and/or certification schemes. Yet, PES often fail in gaining scale (Coudel *et al.* 2015), and market-based interventions can generate conflict and weaken social ties (Pokorny *et al.* 2012). Interestingly, less obvious policies may have important indirect effects on restoration dynamics, such as the Brazilian School Meal Program that has been fundamental in encouraging the consolidation of agroforestry systems and agrobiodiversity in some areas of the eastern Amazon (Resque *et al.* 2019). Understanding the most effective ways to encourage large-scale restoration remains an important research priority.

29.7.3. Community-led restoration

Some site-level restoration actions can be implemented by liaising with a relatively small set of stakeholders, such as property owners or reserve managers. Yet, to achieve sustainable transformations across landscapes and catchments, it is vital that restoration measures are viewed favorably by a broader set of people, including those who live in the landscape or will be affected economically. For example, implementing integrated farming systems on unproductive farmland requires the participation of all relevant stakeholders, both in the design and implementation of the research and extension programs to assure they meet the socio-economic needs and cultural values of the beneficiaries. Unsurprisingly, some of the most successful examples of active restoration involve strong community buy in and leadership. The Xingu Seed Network (Box 29.1) and community-led co-management of fisheries (Campos-Silva et al. 2021) are positive examples of community engagement and leadership. They demonstrate that that success of restoration initiatives involving local people will be highly dependent on effective, long-term support for capacity building and technical assistance, and ongoing and wide-ranging social collaboration and participation (Chapter 30).

29.7.4. Policies

Restoration can also be supported at the national level through official commitments and legislation. For example, the Brazilian National Vegetation

Protection Law (NVPL, or forest code) sets forest-area limits for legal reserves and requires vegetation to be preserved along watercourses and in ecologically-sensitive settings such as steep slopes (Brasil, 2012). The NVPL allows landholders to compensate for past forest clearance by buying forests elsewhere; given issues around permanence, this has provided a mechanism to support restoration of illegal farmland in national parks (Giannichi *et al.* 2018). Yet, national legislation varies greatly across Amazonian countries. Developing a common set of approaches could be encouraged by linking national policies to the many international declarations and incentives that promote restoration, including the New York and Amsterdam declarations, the Bonn Challenge and Initiative 20x20, Sustainable Development Goal 15 Life on Land, the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and additional zero deforestation commitments and policies against imported deforestation.

29.8. Conclusion

To maximize its ecological and societal impact, restoration needs to be implemented in ways that consider its benefits across scales, including at the level of the biome, within landscapes and catchments, and across different groups of local actors and stakeholders. Applying the most appropriate restoration approaches to the right places will require novel prioritization exercises that consider multiple benefits, societal feasibility, ecological need, and the risks posed by climate change.

29.9. References

Abell R, Asquith N, Boccaletti G, *et al.* 2017. Beyond the source: the environmental, economic and community benefits of source water protection. *Arlington, VA: The Nature Conservancy*.

Abell R, Vigerstol K, Higgins J, *et al.* 2019. Freshwater biodiversity conservation through source water protection: quantifying the potential and addressing the challenges. *Aquatic Conservation: Marine and Freshwater Ecosystems* **29**: 1022–38.

Abril G, Martinez J-M, Artigas LF, *et al.* 2014. Amazon River carbon dioxide outgassing fuelled by wetlands. *Nature* **505**: 395–8.

Adams C, Rodrigues ST, Calmon M, and Kumar C. 2016. Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: what we know and do not know. *Biotropica* **48**: 731–44.

Aleixo I, Norris D, Hemerik L, *et al.* 2019a. Amazonian rainforest tree mortality driven by climate and functional traits. *Nature Climate Change* **9**: 384–8.

Aleixo I, Norris D, Hemerik L, *et al.* 2019b. Amazonian rainforest tree mortality driven by climate and functional traits. *Nature Climate Change* **9**: 384–8.

Alix-Garcia J and Gibbs HK. 2017. Forest conservation effects of Brazil's zero deforestation cattle agreements undermined by leakage. *Global Environmental Change* **47**: 201–17.

Alkama R and Cescatti A. 2016. Climate change: Biophysical climate impacts of recent changes in global forest cover. *Science* **351**: 600–4.

Allan JD. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. *Annu Rev Ecol Evol Syst* **35**: 257–84.

Almeida CT, Oliveira-Júnior JF, Delgado RC, *et al.* 2017. Spatiotemporal rainfall and temperature trends throughout the Brazilian Legal Amazon, 1973–2013. *International Journal of Climatology* **37**: 2013–26.

Alteff EF, Gonsioroski G, Barreiros M, *et al.* 2019. The rarest of the rare: rediscovery and status of the critically endangered Belem Curassow, Crax fasciolata pinima (Pelzeln, 1870). *Papéis Avulsos de Zoologia* **59**: e20195946.

Andrea MC da S, Dallacort R, Tieppo RC, and Barbieri JD. 2020. Assessment of climate change impact on double-cropping systems. *SN Applied Sciences* **2**: 1–13.

Arantes CC, Winemiller KO, Asher A, *et al.* 2019. Floodplain land cover affects biomass distribution of fish functional diversity in the Amazon River. *Scientific Reports* **9**: 1–13.

Aronson J and Alexander S. 2013. Ecosystem Restoration is Now a Global Priority: Time to Roll up our Sleeves. *Restoration Ecology* **21**: 293–6.

Arroyo-Rodríguez V, Fahrig L, Tabarelli M, *et al.* 2020. Designing optimal human-modified landscapes for forest biodiversity conservation. *Ecology Letters* **23**: 1404–20.

Barlow J, Berenguer E, Carmenta R, and França F. 2020. Clarifying Amazonia's burning crisis. *Global Change Biology* **26**: 319–21.

Barlow J, Gardner TA, Araujo IS, *et al.* 2007. Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. *Proceedings of the National Academy of Sciences of the United States of America* **104**: 18555–60.

Beechie T, Pess G, Roni P, and Giannico G. 2008. Setting River Restoration Priorities: A Review of Approaches and a General Protocol for Identifying and Prioritizing Actions. *North American Journal of Fisheries Management* **28**: 891–905.

Berenguer E, Gardner TA, Ferreira J, *et al.* 2018. Seeing the woods through the saplings: Using wood density to assess the recovery of human-modified Amazonian forests. *Journal of Ecology*.

Betts, M. G. Wolf, C. Pfeifer, M. Banks-Leite, C. Arroyo-Rodríguez, V. Ribeiro, D. B. ... & Ewers, R. M. (2019). Extinction filters mediate the global effects of habitat fragmentation on animals. Science, 366(6470), 1236-1239.

Bhagwat SA, Willis KJ, Birks HJB, and Whittaker RJ. 2008. Agroforestry: a refuge for tropical biodiversity? *Trends in Ecology and Evolution* **23**: 261–7.

Blignaut J, Esler KJ, Wit MP de, *et al.* 2013. Establishing the links between economic development and the restoration of natural capital. *Current Opinion in Environmental Sustainability* **5**: 94–101.

Bottazzi P, Wiik E, Crespo D, and Jones JPG. 2018. Payment for environmental "self-service": Exploring the links between Farmers' motivation and additionality in a conservation incentive programme in the Bolivian Andes. *Ecological Economics* **150**: 11–23.

Bradshaw CJA, Sodhi NS, Peh KSH, and Brook BW. 2007. Global evidence that deforestation amplifies flood risk and severity in the developing world. *Global Change Biology* **13**: 2379–95.

Bragagnolo C, Gama GM, Vieira FAS, *et al.* 2019. Hunting in Brazil: What are the options? *Perspectives in ecology and conservation* **17**: 71–9.

Brancalion PHS, Almeida DRA de, Vidal E, *et al.* 2018. Fake legal logging in the Brazilian Amazon. *Science advances* **4**: eaat1192.

Brancalion PHS and Chazdon RL. 2017. Beyond hectares: four principles to guide reforestation in the context of tropical forest and landscape restoration. *Restoration Ecology* **25**: 491–6.

Brasil. 2012. Lei 12.641, de 25 de maio de 2012. Viewed

Brêda JPLF, Paiva RCD de Collischon W, *et al.* 2020. Climate change impacts on South American water balance from a continental-scale hydrological model driven by CMIP5 projections. *Climatic Change* **159**: 503–22.

Brondizio ES, Andersson K, Castro F de, *et al.* 2021. Making place-based sustainability initiatives visible in the Brazilian Amazon. *Current Opinion in Environmental Sustainability* **49**: 66–78.

Buytaert W, Célleri R, Bièvre B De, *et al.* 2006. Human impact on the hydrology of the Andean páramos. *Earth-Science Reviews* **79**: 53–72.

Buytaert W, Iniguez V, and Bievre B De. 2007. The effects of afforestation and cultivation on water yield in the Andean páramo. *Forest ecology and management* **251**: 22–30.

Calmon M, Brancalion PHS, Paese A, *et al.* 2011. Emerging Threats and Opportunities for Large-Scale Ecological Restoration in the Atlantic Forest of Brazil. *Restoration Ecology* **19**: 154–8.

Campos-Silva, J. V. Peres, C. A. Hawes, J. E. Haugaasen, T. Freitas, C. T. Ladle, R. J. & Lopes, P. F. (2021). Sustainable use protected areas catalyze enhanced livelihoods in rural Amazonia. Proceedings of the National Academy of Sciences, 118(40).

Carvalho WD De and Mustin K. 2017. The highly threatened and little known Amazonian savannahs. *Nature Ecology and Evolution* **1**: 1–3.

Carvalho WD, Mustin K, Hilário RR, *et al.* 2019. Deforestation control in the Brazilian Amazon: A conservation struggle being lost as agreements and regulations are subverted and bypassed. *Perspectives in Ecology and Conservation* **17**: 122–30.

Castello L and Macedo MN. 2016. Large-scale degradation of Amazonian freshwater ecosystems. *Global Change Biology* **22**: 990–1007.

Celentano D, Rousseau GX, Muniz FH, *et al.* 2017. Towards zero deforestation and forest restoration in the Amazon region of Maranhão state, Brazil. *Land Use Policy* **68**: 692–8.

César RG, Belei L, Badari CG, *et al.* 2021. Forest and Landscape Restoration: A Review Emphasizing Principles, Concepts, and Practices. *Land* **10**: 28.

Chazdon R, Brenes A, and Alvarado B. 2005. Effects of Climate and Stand Age on Annual Tree Dynamics in Tropical Second-Growth Rain Forests on JSTOR. *Ecology* **86**: 1808–15.

Chazdon RL, Broadbent EN, Rozendaal DMA, *et al.* 2016a. Carbon sequestration potential of second-growth forest regeneration in the Latin American tropics. *Science Advances* **2**.

Chazdon RL, Broadbent EN, Rozendaal DMA, *et al.* 2016b. Carbon sequestration potential of second-growth forest regeneration in the Latin American tropics. *Science Advances* **2**: e1501639.

Chazdon RL, Cullen L, Padua SM, and Padua CV. 2020a. People, primates, and predators in the Pontal: from endangered species conservation to forest and landscape restoration in Brazil's Atlantic Forest. *Royal Society Open Science* **7**: 200939.

Chazdon RL, Gutierrez V, Brancalion PHS, *et al.* 2020b. Co-Creating Conceptual and Working Frameworks for Implementing Forest and Landscape Restoration Based on Core Principles. *Forests* **11**: 706.

Coe MT, Costa MH, and Soares-Filho BS. 2009. The influence of historical and potential future deforestation on the stream flow of the Amazon River – Land surface processes and atmospheric feedbacks. *Journal of Hydrology* **369**: 165–74.

Comer PJ, Hak JC, Josse C, and Smyth R. 2020. Long-term loss in extent and current protection of terrestrial ecosystem diversity in the temperate and tropical Americas (SP Aldrich, Ed). *PLoS One* **15**: e0234960.

Constantino P de AL. 2019. Subsistence Hunting with Mixed-Breed Dogs Reduces Hunting Pressure on Sensitive Amazonian Game Species in Protected Areas. *Environmental Conservation* **46**: 92–8.

Cook-Patton SC, Leavitt SM, Gibbs D, *et al.* 2020. Mapping carbon accumulation potential from global natural forest regrowth. *Nature* **585**: 545–50.

Costa-Pereira R, Lucas C, Crossa M, *et al.* 2018. Defaunation shadow on mutualistic interactions. *Proceedings of the National Academy of Sciences* **115**: E2673–5.

Cotula, L. & Mayers, J. (2009). Tenure in REDD: Start-point or Afterthought? (No. 15). IIED.

Coudel E, Ferreira J, Carvalho Amazonas M de, *et al.* 2015. The rise of PES in Brazil: from pilot projects to public policies. In: Handbook of Ecological Economics. Edward Elgar Publishing.

Crouzeilles R, Beyer HL, Monteiro LM, *et al.* 2020. Achieving cost-effective landscape-scale forest restoration through targeted natural regeneration. *Conservation Letters* **13**: e12709.

Dala-Corte RB, Melo AS, Siqueira T, *et al.* 2020. Thresholds of freshwater biodiversity in response to riparian vegetation loss in the Neotropical region. *Journal of Applied Ecology* **57**: 1391–402.

Davidson EA, Araújo AC de, Artaxo P, *et al.* 2012. The Amazon basin in transition. *Nature* **481**: 321–8.

Dias LCP, Macedo MN, Costa MH, *et al.* 2015. Effects of land cover change on evapotranspiration and streamflow of small catchments in the Upper Xingu River Basin, Central Brazil. *Journal of Hydrology: Regional Studies* **4**: 108–22.

Ding H, Faruqi S, Wu A, *et al.* 2017. Roots of Prosperity: The Economics and Finance of Restoring Land The Economics and Finance of Restoring Land. Washington, D. C.

Dixon SJ, Sear DA, Odoni NA, *et al.* 2016. The effects of river restoration on catchment scale flood risk and flood hydrology. *Earth Surface Processes and Landforms* **41**: 997–1008.

Durigan, G. Guerin, N. & da Costa, J. N. M. N. (2013). Ecological restoration of Xingu Basin headwaters: motivations, engagement, challenges and perspectives. Philosophical Transactions of the Royal Society B: Biological Sciences, 368(1619), 20120165.

Edwards DP, Tobias JA, Sheil D, *et al.* 2014. Maintaining ecosystem function and services in logged tropical forests. *Trends in ecology |& evolution* **29**: 511–20.

Elias F, Ferreira J, Lennox GD, *et al.* 2020. Assessing the growth and climate sensitivity of secondary forests in highly deforested Amazonian landscapes. *Ecology* **101**: e02954.

Erbaugh JT and Oldekop JA. 2018. Forest landscape restoration for livelihoods and well-being. *Current Opinion in Environmental Sustainability* **32**: 76–83.

Erbaugh JT, Pradhan N, Adams J, *et al.* 2020. Global forest restoration and the importance of prioritizing local communities. *Nature Ecology and Evolution* **4**: 1472–6.

Esquivel-Muelbert, J. R. Fontoura, L. Zardo, É. Streit, D. P. Esquivel-Muelbert, A. & Garcia, J. R. (2018). Assessing the Viability of Reintroduction of Locally Extinct Migratory Fish Brycon orbignyanus: Successful Growth, Dispersal and Maturation. Fishes, 3(4), 39.

Esquivel-Muelbert A, Baker TR, Dexter KG, *et al.* 2019. Compositional response of Amazon forests to climate change. *Global Change Biology* **25**: 39–56.

Fahrig L, Arroyo-Rodríguez V, Bennett JR, *et al.* 2019. Is habitat fragmentation bad for biodiversity? *Biological Conservation* **230**: 179–86.

Farinosi F, Arias ME, Lee E, *et al.* 2019. Future climate and land use change impacts on river flows in the Tapajós Basin in the Brazilian Amazon. *Earth's Future* **7**: 993–1017.

Feitosa IB, Huszar VLM, Domingues CD, *et al.* 2019. Plankton community interactions in an Amazonian floodplain lake, from bacteria to zooplankton. *Hydrobiologia* **831**: 55–70.

Ferraz G, Russell GJ, Stouffer PC, *et al.* 2003. Rates of species loss from Amazonian forest fragments. *Proceedings of the National Academy of Sciences* **100**: 14069–73.

Ferreira J, Lennox GD, Gardner TA, *et al.* 2018. Carbon-focused conservation may fail to protect the most biodiverse tropical forests. *Nature Climate Change* **8**: 744–9.

Filoso S, Bezerra MO, Weiss KCB, and Palmer MA. 2017. Impacts of forest restoration on water yield: A systematic review. *PloS one* **12**: e0183210.

Flecker AS, McIntyre PB, Moore JW, *et al.* 2010. Migratory fishes as material and process subsidies in riverine ecosystems. In: American Fisheries Society Symposium.

Fletcher RJ, Didham RK, Banks-Leite C, *et al.* 2018. Is habitat fragmentation good for biodiversity? *Biological Conservation* **226**: 9–15.

Flores BM, Holmgren M, Xu C, *et al.* 2017. Floodplains as an Achilles' heel of Amazonian forest resilience. *Proceedings of the National Academy of Sciences of the United States of America* **114**.

Food and Agriculture Organization of the United Nations and International Tropical Timber Organization. 2011. The State of Forests in the Amazon Basin, Congo Basin and Southeast Asia.

Fortmann L and Bruce J. 1991. You've got to know who controls the land and trees people use: gender, tenure and the environment. University of Zimbabw (UZ).

Freeman MC, Pringle CM, Greathouse EA, and Freeman BJ. 2003. Ecosystem-level consequences of migratory faunal depletion caused by dams. In: American Fisheries Society Symposium.

Garcia-Carreras L and Parker DJ. 2011. How does local tropical deforestation affect rainfall? *Geophysical Research Letters* **38**: n/a-n/a.

Garrett RD, Gardner TA, Fonseca Morello T, *et al.* 2017. Explaining the persistence of low income and environmentally degrading land uses in the Brazilian Amazon. *Ecology and Society* **22**.

Garrett RD, Koh I, Lambin EF, *et al.* 2018. Intensification in agriculture-forest frontiers: Land use responses to development and conservation policies in Brazil. *Global Environmental Change* **53**: 233–43.

Giannichi ML, Dallimer M, Baker TR, *et al.* 2018. Divergent Landowners' Expectations May Hinder the Uptake of a Forest Certificate Trading Scheme. *Conservation Letters* **11**: e12409.

Goldman R, Ben\'\itez S, Calvache A, and Montambault J. 2010. Measuring the effectiveness of water funds: guidance document for development of impact measures. *TNC, Arlington, Virginia*.

Hall A, Chiu Y, and Selker JS. 2020. Coupling high-resolution monitoring and modelling to verify restoration-based temperature improvements. *River Research and Applications* **36**: 1430–41.

Harris JA, Hobbs RJ, Higgs E, and Aronson J. 2006. Ecological restoration and global climate change.

Haugaasen T and Peres CA. 2007. Vertebrate responses to fruit production in Amazonian flooded and unflooded forests. *Biodiversity and Conservation* **16**: 4165–90.

Hayhoe SJ, Neill C, Porder S, *et al.* 2011. Conversion to soy on the Amazonian agricultural frontier increases streamflow without affecting stormflow dynamics. *Global Change Biology* **17**: 1821–33.

Heinrich VHA, Dalagnol R, Cassol HLG, *et al.* 2021. Large carbon sink potential of secondary forests in the Brazilian Amazon to mitigate climate change. *Nature Communications* **12**: 1–11.

Higgins J V and Zimmerling A. 2013. A Primer for Monitoring Water Funds. Arlington, VA: The Nature Conservancy. 2013.

Hoegh-Guldberg O, Jacob D, Taylor M, *et al.* 2018. Impacts of 1.5ºC global warming on natural and human systems. IPCC.

Holdsworth AR and Uhl C. 1997. Fire in Amazonian selectively logged rain forest and the potential for fire reduction. *Ecological Applications* **16**: 440–51.

Hurd LE, Sousa RGC, Siqueira-Souza FK, *et al.* 2016. Amazon floodplain fish communities: Habitat connectivity and conservation in a rapidly deteriorating environment. *Biological Conservation* **195**: 118–27.

Hutyra LR, Munger JW, Nobre CA, *et al.* 2005. Climatic variability and vegetation vulnerability in Amazônia. *Geophysical Research Letters* **32**: L24712.

Ianni, E. & Geneletti, D. (2010). Applying the ecosystem approach to select priority areas for forest landscape restoration in the Yungas, Northwestern Argentina. Environmental management, 46(5), 748-760.

Jackson ST and Hobbs RJ. 2009. Ecological restoration in the light of ecological history. *Science* **325**: 567–9.

Jakovac CC, Peña-Claros M, Kuyper TW, and Bongers F. 2015. Loss of secondary-forest resilience by land-use intensification in the Amazon. *Journal of Ecology* **103**: 67–77.

Jong W de, Zon M van der, Urushima AF, *et al.* 2018. Tenure, property rights and forest landscape restoration. *Forest Landscape Restoration: Integrated Approaches to Support Effective Implementation*: 158–75.

Junk WJ, Bayley PB, Sparks RE, and others. 1989. The flood pulse concept in river-floodplain systems. *Canadian special publication of fisheries and aquatic sciences* **106**: 110–27.

Kratter AW. 1997. Bamboo Specialization by Amazonian Birds1. *Biotropica* **29**: 100–10.

Kremen C and Merenlender AM. 2018. Landscapes that work for biodiversity and people. *Science* **362**.

L. Resque A, Coudel E, Piketty M-G, *et al.* 2019. Agrobiodiversity and Public Food Procurement Programs in Brazil: Influence of Local Stakeholders in Configuring Green Mediated Markets. *Sustainability* **11**: 1425.

Lamb D, Erskine PD, and Parrotta JA. 2005. Restoration of degraded tropical forest landscapes. *Science* **310**: 1628–32.

Lamb D, Stanturf J, and Madsen P. 2012. What Is Forest Landscape Restoration? : 3–23.

Leal CG, Lennox GD, Ferraz SFB, *et al.* 2020. Integrated terrestrial-freshwater planning doubles conservation of tropical aquatic species. *Science* **370**: 117–21.

Lee M and Hancock P. 2011. Restoration and Stewardship Volunteerism. In: Human Dimensions of Ecological Restoration. Washington, DC: Island Press/Center for Resource Economics.

Lees AC, Attwood S, Barlow J, and Phalan B. 2020. Biodiversity scientists must fight the creeping rise of extinction denial. *Nature Ecology & Evolution 2020 4:11* **4**: 1440–3.

Lees AC, Moura NG, Almeida AS, and Vieira ICG. 2014. Noteworthy ornithological records from the threatened campinas of the lower rio Tocantins, east Amazonian Brazil. *Bulletin of the British Ornithologists' Club* **134**: 247–58.

Lees AC and Peres CA. 2006. Rapid avifaunal collapse along the Amazonian deforestation frontier. *Biological Conservation* **133**: 198–211.

Lees AC and Peres CA. 2009. Gap-crossing movements predict species occupancy in Amazonian forest fragments. *Oikos* **118**: 280–90.

Leitold V, Morton DC, Longo M, *et al.* 2018. El Niño drought increased canopy turnover in Amazon forests. *New Phytologist* **219**: 959–71.

Lewis SL, Wheeler CE, Mitchard ETA, and Koch A. 2019. Restoring natural forests is the best way to remove atmospheric carbon. *Nature* **568**: 25–8.

Lima LS, Coe MT, Soares Filho BS, *et al.* 2014. Feedbacks between deforestation, climate, and hydrology in the Southwestern Amazon: implications for the provision of ecosystem services. *Landscape ecology* **29**: 261–74.

Lohbeck M, Poorter L, Lebrija-Trejos E, *et al.* 2013. Successional changes in functional composition contrast for dry and wet tropical forest. *Ecology* **94**: 1211–6.

Lovejoy TE and Nobre C. 2018. Amazon tipping point.

Luke SH, Slade EM, Gray CL, *et al.* 2019. Riparian buffers in tropical agriculture: Scientific support, effectiveness and directions for policy. *Journal of Applied Ecology* **56**: 85–92.

Macedo MN, Coe MT, DeFries R, *et al.* 2013a. Land-use-driven stream warming in southeastern Amazonia. *Philosophical Transactions of the Royal Society B: Biological Sciences* **368**: 20120153.

Macedo MN, Coe MT, DeFries R, *et al.* 2013b. Land-use-driven stream warming in southeastern Amazonia. *Philosophical Transactions of the Royal Society B: Biological Sciences* **368**: 20120153.

Maginnis Stewart and Jackson W. 2012. What is FLR and How Does It Differ from Current Approaches? : 19–34.

Mansourian S. 2016. Understanding the Relationship between Governance and Forest Landscape Restoration. *Conservation and Society* **14**: 267–78.

Mansourian S. 2017. Governance and forest landscape restoration: A framework to support decision-making. *Journal for Nature Conservation* **37**: 21–30.

Mansourian S and Vallauri D. 2005. Forest landscape restoration in context. *Forest Restoration in Landscapes: Beyond Planting Trees*: 3–7.

Marengo JA. 2009. Long-term trends and cycles in the hydrometeorology of the Amazon basin since the late 1920s. *Hydrological Processes* **23**: 3236–44.

Margules CR and Pressey RL. 2000. Systematic conservation planning. *Nature* **405**: 243–53.

Mather AS. 1992. The forest transition. *Area* **24**: 367–79.

McClain ME and Naiman RJ. 2008. Andean influences on the biogeochemistry and ecology of the Amazon River. *BioScience* **58**: 325–38.

McDowell N, Allen CD, Anderson-Teixeira K, *et al.* 2018. Drivers and mechanisms of tree mortality in moist tropical forests. *New Phytologist* **219**: 851–69.

McIntosh EJ, Pressey RL, Lloyd S, *et al.* 2017. The impact of systematic conservation planning. *Annual Review of Environment and Resources* **42**: 677–97.

Meerveld HJ (Ilja) van, Jones JPG, Ghimire CP, *et al.* 2021. Forest regeneration can positively contribute to local hydrological ecosystem services: Implications for forest landscape restoration (L Flory, Ed). *Journal of Applied Ecology* **58**: 755–65.

Mendes CB and Prevedello JA. 2020. Does habitat fragmentation affect landscape-level temperatures? A global analysis. *Landscape Ecology* **35**: 1743–56.

Meyfroidt, P. & Lambin, E. F. (2011). Global forest transition: prospects for an end to deforestation. Annual review of environment and resources, 36, 343-371.

Moore RP, Robinson WD, Lovette IJ, and Robinson TR. 2008. Experimental evidence for extreme dispersal limitation in tropical forest birds. *Ecology Letters* **11**: 960–8.

Muradian R, Arsel M, Pellegrini L, *et al.* 2013. Payments for ecosystem services and the fatal attraction of win-win solutions. *Conservation Letters* **6**: 274–9.

Negrón-Juárez RI, Chambers JQ, Guimaraes G, *et al.* 2010. Widespread Amazon forest tree mortality from a single cross-basin squall line event. *Geophysical Research Letters* **37**: n/a-n/a.

Ngo Bieng MA, Souza Oliveira M, Roda J-M, *et al.* 2021. Relevance of secondary tropical forest for landscape restoration. *Forest Ecology and Management* **493**: 119265.

Nepstad, D. C. de Carvalho, C. R. Davidson, E. A. Jipp, P. H. Lefebvre, P. A. Negreiros, G. H. ... & Vieira, S. (1994). The role of deep roots in the hydrological and carbon cycles of Amazonian forests and pastures. Nature, 372(6507), 666-669.

Nobre CA, Sampaio G, Borma LS, *et al.* 2016. Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. *Proceedings of the National Academy of Sciences* **113**: 10759–68.

Nobre CA, Sellers PJ, and Shukla J. 1991. Amazonian Deforestation and Regional Climate Change. *Journal of Climate* **4**: 957–88.

Nóbrega RLB, Ziembowicz T, Torres GN, *et al.* 2020. Ecosystem services of a functionally diverse riparian zone in the Amazon--Cerrado agricultural frontier. *Global Ecology and Conservation* **21**: e00819.

Ochoa-Tocachi BF, Buytaert W, Bièvre B De, *et al.* 2016. Impacts of land use on the hydrological response of tropical Andean catchments. *Hydrological Processes* **30**: 4074–89.

Oosten C van, Runhaar H, and Arts B. 2021. Capable to govern landscape restoration? Exploring landscape governance capabilities, based on literature and stakeholder perceptions. *Land Use Policy* **104**: 104020.

Ota L, Chazdon RL, Herbohn J, *et al.* 2020. Achieving Quality Forest and Landscape Restoration in the Tropics. *Forests* **11**: 820.

Oyama MD and Nobre C. 2003. A new climate-vegetation equilibrium state for Tropical South America. *Geophysical Research Letters* **30**: 10–3.

Palmer MA, Bernhardt ES, Allan JD, *et al.* 2005. Standards for ecologically successful river restoration. *Journal of Applied Ecology* **42**: 208–17.

Peres CA. 2001. Synergistic effects of subsistence hunting and habitat fragmentation on Amazonian forest vertebrates. *Conservation biology* **15**: 1490–505.

Peterjohn WT and Correll DL. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. *Ecology* **65**: 1466–75.

Philipson CD, Cutler MEJ, Brodrick PG, *et al.* 2020. Active restoration accelerates the carbon recovery of human-modified tropical forests. *Science* **369**: 838–41.

Phillips OL, Aragão LEOC, Lewis SL, *et al.* 2009. Drought sensitivity of the amazon rainforest. *Science* **323**: 1344–7.

Piponiot C, Rödig E, Putz FE, *et al.* 2019a. Can timber provision from Amazonian production forests be sustainable? *Environmental Research Letters* **14**: 064014.

Piponiot C, Rödig E, Putz FE, *et al.* 2019b. Can timber provision from Amazonian production forests be sustainable? *Environmental Research Letters* **14**: 064014.

Piva Da Silva M. 2017. Livelihoods, Capabilities and Insurgent Citizenship in and around a rainforest metropolis: from violent urbanism to a new rurality?

Poff NL, Allan JD, Bain MB, *et al.* 1997. The natural flow regime. *BioScience* **47**: 769–84.

Pokorny B, Johnson J, Medina G, and Hoch L. 2012. Market-based conservation of the Amazonian forests: Revisiting win–win expectations. *Geoforum* **43**: 387–401.

Poorter, L. Rozendaal, D. M. Bongers, F. de Almeida-Cortez, J. S. Zambrano, A. M. A. Álvarez, F. S. ... & Westoby, M. (2019). Wet and dry tropical forests show opposite successional pathways in wood density but converge over time. Nature ecology & evolution, 3(6), 928-934.

Putz FE, Sist P, Fredericksen T, and Dykstra D. 2008. Reduced-impact logging: challenges and opportunities. *Forest ecology and management* **256**: 1427–33.

Putz FE, Zuidema PA, Synnott T, *et al.* 2012. Sustaining conservation values in selectively logged tropical forests: the attained and the attainable. *Conservation Letters* **5**: 296–303.

O'Brien, M. J. Philipson, C. D. Reynolds, G. Dzulkifli, D. Snaddon, J. L. Ong, R. & Hector, A. (2019). Positive effects of liana cutting on seedlings are reduced during El Niño-induced drought. Journal of Applied Ecology, 56(4), 891-901.

Qie L, Telford EM, Massam MR, *et al.* 2019. Drought cuts back regeneration in logged tropical forests. *Environmental Research Letters* **14**: 045012.

RAISG. 2020. Amazonian Network of Georeferenced Socio-Environmental Information https://www.amazoniasocioambiental.org/en/.

Ray D, Nepstad D, and Moutinho P. 2005. Micrometeorological and canopy controls of flammability in mature and disturbed forests in an east-central Amazon landscape. *Ecol Appl* **15**: 2.

Reed MS. 2008. Stakeholder participation for environmental management: A literature review. *Biological Conservation* **141**: 2417–31.

Reed J, Barlow J, Carmenta R, *et al.* 2019. Engaging multiple stakeholders to reconcile climate, conservation and development objectives in tropical landscapes. *Biological Conservation* **238**: 108229.

Reed J, Vianen J Van, Deakin EL, *et al.* 2016a. Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future. *Global change biology* **22**: 2540–54.

Reed J, Vianen J Van, Deakin EL, *et al.* 2016b. Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future. *Global change biology* **22**: 2540–54.

Rodrigues ASL, Ewers RM, Parry L, *et al.* 2009. Boom-and-Bust Development Patterns Across the Amazon Deforestation Frontier. *Science* **324**: 1435–7.

Rossi, Jacques Garcia Alain Roques J and Rousselet J-P. 2016. Trees outside forests in agricultural landscapes: spatial distribution and impact on habitat connectivity for forest organisms. *Landscape Ecology* **31**: 243–54.

Saad SI, Silva J da, Silva MLN, *et al.* 2018. Analyzing ecological restoration strategies for water and soil conservation. *Plos one* **13**: e0192325.

Sabogal C, Besacier C, and McGuire D. 2015. Forest and landscape restoration: Concepts, approaches and challenges for implementation. *Unasylva* **66**: 3.

Sampaio G, Nobre C, Costa MH, *et al.* 2007a. Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. *Geophysical Research Letters* **34**: L17709.

Sampaio G, Nobre C, Costa MH, *et al.* 2007b. Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. *Geophysical Research Letters* **34**: L17709.

Sanches, R. A. Futemma, C. R. T. & Alves, H. Q. (2021). Indigenous territories and governance of forest restoration in the Xingu River (Brazil). Land Use Policy, 104, 104755.

Sayer J, Sunderland T, Ghazoul J, *et al.* 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences of the United States of America* **110**: 8349–56.

Schiesari L, Waichman A, Brock T, *et al.* 2013. Pesticide use and biodiversity conservation in the Amazonian agricultural frontier. *Philosophical Transactions: Biological Sciences* **368**: 1–9.

Schmidt IB, Urzedo DI de, Piña-Rodrigues FCM, *et al.* 2019. Community-based native seed production for restoration in Brazil – the role of science and policy. *Plant Biology* **21**: 389–97.

Schneider CL, Herrera M, Raisle ML, *et al.* 2020. Carbon Dioxide (CO2) Fluxes from Terrestrial and Aquatic Environments in a High-Altitude Tropical Catchment. *Journal of Geophysical Research: Biogeosciences* **125**: e2020JG005844.

Schulze MD. 2003. Ecology and behavior of nine timber tree species in Pará, Brazil: links between species life history and forest management and conservation.

Schwartzman S, Boas AV, Ono KY, *et al.* 2013. The natural and social history of the indigenous lands and protected areas corridor of the Xingu River basin. *Philosophical Transactions of the Royal Society B: Biological Sciences* **368**: 20120164.

Silva Junior CHL, Aragão LEOC, Anderson LO, *et al.* 2020. Persistent collapse of biomass in Amazonian forest edges following deforestation leads to unaccounted carbon losses. *Science Advances* **6**: eaaz8360.

Sist P and Ferreira FN. 2007. Sustainability of reduced-impact logging in the Eastern Amazon. *Forest ecology and management* **243**: 199–209.

Sist P, Piponiot C, Kanashiro M, *et al.* 2021. Sustainability of Brazilian forest concessions. *Forest Ecology and Management* **496**: 119440.

Schmidt, I. B. de Urzedo, D. I. Piña-Rodrigues, F. C. M. Vieira, D. L. M. de Rezende, G. M. Sampaio, A. B. & Junqueira, R. G. P. (2019). Community-based native seed production for restoration in Brazil–the role of science and policy. Plant Biology, 21(3), 389-397.

Smith CC, Healey J, Berenguer E, *et al.* 2021. Old-growth forest loss and secondary forest recovery across Amazonian countries. *Environmental Research Letters*.

Smith MN, Taylor TC, Haren J van, *et al.* 2020. Empirical evidence for resilience of tropical forest photosynthesis in a warmer world. *Nature Plants* **6**: 1225–30.

Staal A, Tuinenburg OA, Bosmans JHC, *et al.* 2018. Forest-rainfall cascades buffer against drought across the Amazon. *Nature Climate Change* **8**: 539–43.

Stanturf JA, Kant P, Lillesø J-PB, *et al.* 2015. Forest landscape restoration as a key component of climate change mitigation and adaptation. International Union of Forest Research Organizations (IUFRO) Vienna, Austria.

Stanturf JA, Kleine M, Mansourian S, *et al.* 2019. Implementing forest landscape restoration under the Bonn Challenge: a systematic approach. *Annals of Forest Science* **76**: 1–21.

Strassburg BBN, Iribarrem A, Beyer HL, *et al.* 2020. Global priority areas for ecosystem restoration. *Nature* **586**: 724–9.

Sullivan MJP, Lewis SL, Affum-Baffoe K, *et al.* 2020. Long-term thermal sensitivity of earth's tropical forests. *Science* **368**: 869–74.

Tembata, K. Yamamoto, Y. Yamamoto, M. & Matsumoto, K. I. (2020). Don't rely too much on trees: Evidence from flood mitigation in China. Science of The Total Environment, 732, 138410.

Tregidgo DJ, Barlow J, Pompeu PS, *et al.* 2017. Rainforest metropolis casts 1,000-km defaunation shadow. *Proceedings of the National Academy of Sciences* **114**: 8655–9.

Uriarte M, Schwartz N, Powers JS, *et al.* 2016. Impacts of climate variability on tree demography in second growth tropical forests: the importance of regional context for predicting successional trajectories. *Biotropica* **48**: 780–97.

Urzedo, D. I. Vidal, E. Sills, E. O. Piña-Rodrigues, F. C. M. & Junqueira, R. G. P. (2016). Tropical forest seeds in the household economy: effects of market participation among three sociocultural groups in the Upper Xingu region of the Brazilian Amazon. Environmental Conservation, 43(1), 13-23.

Vannote RL, Minshall GW, Cummins KW, *et al.* 1980. The river continuum concept. *Canadian journal of fisheries and aquatic sciences* **37**: 130–7.

Verschuuren, B. Subramanian, S. M. & Hiemstra, W. (2014). Community Well-being in Biocultural Landscapes: Are We Living Well?. Practical Action Publishing Ltd.

Venticinque E, Forsberg B, Barthem R, *et al.* 2016. An explicit GIS-based river basin framework for aquatic ecosystem conservation in the Amazon. https://knb.ecoinformatics.org/view/doi%3A10.5063%2FF1BG2KX8#snapp_computing.6.1.

Ward J V. 1989. The four-dimensional nature of lotic ecosystems. *Journal of the North American Benthological Society* **8**: 2–8.

Waroux Y le P de, Garrett RD, Heilmayr R, and Lambin EF. 2016. Land-use policies and corporate investments in agriculture in the Gran Chaco and Chiquitano. *Proceedings of the National Academy of Sciences* **113**: 4021–6.

Wilson SJ, Schelhas J, Grau R, *et al.* 2017. Forest ecosystem-service transitions: The ecological dimensions of the forest transition. *Ecology and Society* **22**.

Wohl E, Bledsoe BP, Jacobson RB, *et al.* 2015. The natural sediment regime in rivers: Broadening the foundation for ecosystem management. *BioScience* **65**: 358–71.

Zanetti PS, Crouzeilles R, and Sansevero JBB. 2019. Can agroforestry systems enhance biodiversity and ecosystem service provision in agricultural landscapes? A meta-analysis for the Brazilian Atlantic Forest. *Forest Ecology and Management* **433**: 140–5.

Zhang J, Bruijnzeel LA, Tripoli R, and Meerveld HJI van. 2019. Water budget and run-off response of a tropical multi-species "reforest" and effects of typhoon disturbance. *Ecohydrology* **12**: e2055.

Chapter 30

The new bioeconomy in the Amazon: Opportunities and challenges for a healthy standing forest and flowing rivers

Mulheres indígenas sateré mawé abrem loja de artesanado (Foto: Alberto César Araújo/Amazônia Real)

INDEX

GRAPHICAL ABSTRACT **2**

KEY MESSAGES **3**

ABSTRACT **4**

30.1 INTRODUCTION **4**

30.1.1 An immense unrealized potential 5

30.2 BIOECONOMY: MORE THAN A SECTOR, AN ETHICAL IMPERATIVE **9**

30.2.1 Why a new bioeconomy of healthy standing forests and rivers flowing? 10
30.2.2 Bioeconomy: A path to scientific and technological innovation frontier 11

30.3 DIVERSITY, THE KEY FEATURE OF BIOECONOMY IN THE AMAZON **12**

30.4 THE CURRENT LIMITED ECONOMY OF FOREST SOCIO-BIODIVERSITY **14**

30.4.1 Timber/wood 16
30.4.2 Non-timber forest products 19
30.4.3 Fishing and pisciculture 22

30.5 BIOECONOMY SERVICES **25**

30.5.1 Synergies between bioeconomy and forest restoration 25
30.5.1.1 Fruit Trees *26*
30.5.1.2 Timber *30*
30.5.1.3 Other Products *30*
30.5.2 Tourism 31
30.5.3 Payment for Environmental Services 33

30.6 AN EMERGING TRANSITION **34**

30.6.1 The diversity of actors 36

30.7 NAVIGATING THE NEW BIOECONOMY: CHALLENGES AND RECOMMENDATIONS **37**

30.7.1 Cities, infrastructure, and internal markets 38
30.7.2 Reduce information asymmetry 39
30.7.3 Seals of quality, scale, and entrepreneurship 39
30.7.4 Governmental support for strengthening markets 42
30.7.5 Science, Technology, and Innovation 42
30.7.6 Biodiversity molecules and shared benefits 43
30.7.7 State and local information systems 44

30.8 CONCLUSIONS **44**

30.9 REFERENCES **45**

Graphical Abstract

Figure 30.A Key premises for the emergence of a new bioeconomy of healthy, standing forests and flowing rivers.

The New Bioeconomy in the Amazon: Opportunities and Challenges for Healthy, Standing Forests and Flowing Rivers

Ricardo Abramovay[a], Joice Ferreira[b*], Francisco de Assis Costa[c], Marco Ehrlich[d], Ana Margarida Castro Euler[e], Carlos Eduardo F. Young[f], David Kaimowitz[g], Paulo Moutinho[h], Ismael Nobre[i], Herve Rogez[c], Eduardo Roxo[j], Tatiana Schor[k], Luciana Villanova[l]*

Key Messages

- The Amazon is far from the scientific and technological frontier of the contemporary bioeconomy. The sustainable use of its socio-biodiversity is the main path for it to continue providing ecosystem services essential for life on the planet. At the same time, this provides opportunities to improve the living conditions of rural, forest, and urban populations, currently characterized by poverty, inequality, and threats to citizens' rights.
- Making forest socio-biodiversity the epicenter of sustainable economic development requires recognizing the importance of knowledge accumulated by forest peoples over millennia, as well as valuing current regenerative practices of increasing importance in the region.
- A bioeconomy is more than an economic sector. It synthesizes a set of ethical-normative values on the relationship between society and nature and their consequences. The bioeconomy has the ambition to guide social life towards the regenerative use of the biotic, material, and energy resources on which we all depend. The opportunities that open up for combating poverty and inequality with the sustainable use of forest biodiversity are immense, not only in rural areas but also in cities.
- The social and economic base for the sustainable use of standing forests and flowing rivers is broad and diverse. It involves the traditional activities of forest peoples, family farming marked by land uses characterized by rich biodiversity, and all the actors in rural landscapes. Commodity agriculture focused on the production of grain and meat also has an important role to play, promoting regenerative practices and avoiding socioenvironmental harm.
- Growing global attention on forest devastation has mobilized diverse social and political forces in the Amazon in search of alternatives to predatory forms of development. International agreements, such as the Leticia Pact, stand out in this context, in addition to actions by subnational governments, coalitions of civil society organizations, companies, scientists, and representatives of forest peoples to promote the transition to a knowledge economy for nature.
- One of the most important premises for the emergence of a new bioeconomy is to change the conception and forms of implementation of planned infrastructure projects. Environmentally-sensitive planning that meets the population's basic needs, such as high-quality connections, agile transport ser-

[a] Instituto de Energia e Ambiente da Universidade de São Paulo, R. da Reitoria 374, Cidade Universitária, Butantã, São Paulo SP 05508-220, Brazil, abramov@usp.br
[b] Embrapa Eastern Amazon, Trav. Dr. Enéas Pinheiro s/n°, Bairro Marco, 66095-903 Belém PA, Brazil, joice.ferreira@embrapa.br
[c] Federal University of Pará, R. Augusto Corrêa 01, Guamá, Belém PA 66075-110, Brazil
[d] Instituto Amazónico de Investigaciones Científicas (SINCHI), Avenida Vásquez Cobo Entre Calles 15 Y 16, Leticia, Colombia
[e] Embrapa Amapá, Rodovia Juscelino Kubitscheck, Km 5, nº 2600, Universidade, Macapá AP 68903-419, Brazil
[f] Institute of Economics, Federal University of Rio de Janeiro, Av. Pasteur 250, Urca, Rio de Janeiro RJ 21941-901, Brazil
[g] Climate and Land Use Alliance, 235 Montgomery Street, 13th Floor, San Francisco CA 94104, U.S.A.
[h] Amazon Environmental Research Institute (IPAM), Av. Nazaré 669, Centro, Belém PA 66040-145, Brazil
[i] Amazônia 4.0, Parque Tecnológico UNIVAP, Avenida Shishima Hifumi 2911, Sala 401, São José dos Campos SP 12244-390, Brazil
[j] ATINA - Ativos Naturais Ltda, Rua Américo Brasiliense 615, sala 01, Chácara St. Antonio, São Paulo SP 04715-003, Brazil
[k] Federal University of Amazonas, Av. General Rodrigo Octavio Jordão Ramos 1200, Coroado I, Manaus AM 69067-005, Brazil
[l] Natura, Av. Alexandre Colares 1188, Vila Jaguara, São Paulo SP 05106-000, Brazil

vices, and high-quality information to improve the commercialization of products, are basic objectives to which, in most cases, current infrastructure does not respond.
- The Amazon has several respected science and technology teaching and research organizations. With appropriate institutional investments and international collaboration, a new bioeconomy of healthy, standing forests and flowing rivers can emerge.

Abstract

In the past twenty years, the bioeconomy has been increasingly recognized for its potential to create value and its contribution to sustainable development. Although most of the world's biodiversity is located in tropical regions, the main players generating scientific and technological literature on the bioeconomy are situated far from tropical forests. The chapter's fundamental starting point is the recognition that the Amazon's ecosystems have been occupied by people who have accumulated a deep knowledge about them, interacting and decisively contributing to its maintenance for thousands of years. It is critical to understand, highlight, and demonstrate the strategic role that Amazonian ecosystems and local people can and should play in the global emergence of the bioeconomy. Evidence is accumulating on the enormous potential to produce a range of products and improve the well-being of people from these forests. This strategic role is not straightforward because of the natural attributes of their ecosystems: a sustainable pathway to the bioeconomy has yet to be built, and should go through several fundamental elements, including: a) Recognition that, by ethical principles, strengthening the forest economy should support the improvement of local livelihoods; b) Institutional signaling against illegality and deforestation; c) Improvement in the quality of information about different products and their value chains; and d) Provoking the emergence of dynamic markets as alternatives to the incomplete, socially unfair, and imperfect markets that dominate the forest economy today. This chapter paves the way for a new vision of a healthy, standing forest and flowing river bioeconomy. First, it presents the bioeconomy as a recent field with no unified definition in international literature. After this, it describes how the bioeconomy of forest socio-biodiversity in the Amazon is still very limited. The low economic efficiency of current ways of using the forest is discussed, and the current economic exploitation of forest socio-biodiversity in three basic sectors are presented: timber, non-timber products, and fishing. Then, the following services related to the bioeconomy are presented: synergies with forest restoration, tourism, and payment for ecosystem services. Finally, it discusses the transition needed for healthy, standing forests and flowing rivers to become a vector for the prosperity of populations and solutions for global socio-environmental challenges.

Keywords: Bioeconomy, socio-biodiversity, standing forests, flowing rivers, tropical forests, Amazon.

30.1 Introduction

The starting point for stimulating the emergence of a strong and dynamic socio-biodiverse economy in the Amazon is recognizing that the most important tropical forest in the world has been occupied by people who have known how to make use of its immense wealth and have decisively contributed to its maintenance for thousands of years. In the pre-Columbian period, it is estimated that 8 to 10 million people lived in the Amazon, many of whom in villages of 10,000 inhabitants (Clement *et al.* 2015; see Chapters 8-10). Dense population clusters were recorded in the sixteenth century by Gaspar de Carvajal, a Dominican friar that accompanied Francisco de Orellana on his trip on the Amazon River (Plotkin 2020:101).

The social activities of these peoples were not based on the destruction of the forest. On the contrary, they decisively contributed to what the ethnobotanist William Balée (2013) called an "anthropogenic forest". Part of the current forest formation in the Amazon is a result of the management of various environments to "increase the abundance of plants used as food or fiber" (Plotkin 2020: 102; see Chapter 10). Ethnobotanical studies in the twentieth century increased our knowledge not only of flora, microorganisms, and the immense Amazon fauna, but also of their constant interaction with human populations (Schultes and von Reis 1995).

Despite the violence European colonization inflicted upon the Amazon's original peoples (see Chapter 9) and the promotion in the last fifty years of an economy based on the destruction of nature (Hern 1991; see also Chapters 14–20), the Amazon can still decisively contribute to solving some of the most relevant contemporary problems. This is due not only to the ecosystem services provided by the forest (Phillips *et al.* 2017; see Chapters 4–8), such as its function as a carbon sync (Yang *et al.* 2018), but also due to its biodiversity (Barlow *et al.* 2018; see Chapter 3) and the knowledge, techniques, and economic practices of the peoples who inhabit it (see Chapters 8, 10, and 13).

Today, this immense potential is underutilized (Vietmeyer 2008) and being systematically destroyed by deforestation and degradation, growing aggression against forest dwellers and their territories, extractivism that barely benefits those who live in the region, and frequently low-productivity agriculture and cattle ranching (see Chapters 14–20). Expansion of the agricultural frontier has been associated with degradation of the fundamental ecosystem services on which human societies depend (Garrett *et al.* 2017), starting with climate regulation, water supply, and biodiversity (see Chapters 17–24). Amazonian urban populations also do not benefit from land-use practices that degrade their wealth and export the very results of this destruction outside the region (Costa and Brondizio 2009). Infrastructure investments aim to make the Amazon a supplier of energy, minerals, and agricultural commodities, with benefits accumulating to those that live far from the Amazon's rural and urban areas (Chiavari *et al.* 2020; Antonaccio *et al.* 2020; Bebbington *et al.* 2020).

The fires that shocked the world in 2019, darkening the São Paulo sky in broad daylight (Setzer 2019; Barlow *et a*l. 2020), raised awareness of the prevailing illegality and criminality in the region (Abdenur *et al.* 2020). These events drew attention mainly to the complacent attitude of several government administrations and agencies who promoted destructive practices in the name of supposed production of wealth. They often supported predatory practices, such as the invasion of Indigenous peoples' territories, the occupation of public areas, or illegal mining. More than that, these fires highlighted one of the most important paradoxes of the twenty-first century: the Amazon (and other tropical forests) are still not part of the scientific, technological, or market frontier of the contemporary bioeconomy. At the same time, aggression toward the forest and the people that currently inhabit it sheds even more light on an indispensable challenge that needs to be overcome for a strong and dynamic bioeconomy to take hold in the Amazon: transformation away from current agriculture and livestock commodities towards a sector that contributes to forest regeneration and offers goods and services that are recognized by different markets as strengthening of biodiversity. This orientation cannot be limited to forest areas. It must also reach the diversity of land use models in the Amazon, including the commodity production sector, wood production, forest regeneration, and mining. As discussed later in this chapter, the experience from farms that already use regenerative production methods and from hundreds of thousands of family farmers who enable their production through a rich polyculture, shows an abundant and diffused knowledge of the use of the forest. These current economic practices contain, albeit to a limited extent, precious lessons in the direction toward the sustainable development of rural areas in the Amazon.

30.1.1 An Immense Unrealized Potential

Literature on the socio-biodiversity of the Amazon and continues to grow, as shown by research programs, reports, and conferences connected to the most important botanical gardens in the world, as well as by interdisciplinary research from the region as well as international universities and laboratories. Evidence that destruction of the Amazon means the loss of valuable economic resources has been presented throughout the twentieth century (e.g., Rodrigues *et al.* 2009).

In 1941, Celestino Pesce published "Oilseeds from the Amazon", in which he studied a variety of native species. Many products were processed locally and exported, nationally and internationally. Pesce (1941) was an industrialist and, in 1913, bought a factory for processing ucuuba (*Virola surinamensis* (Rol.) Warb.). At the same time, his research resulted in a book, whose preface highlights the scarcity of use of an extraordinary and unique wealth.

In 1979, Richard Evans Schultes published a text in which he praised the Amazon as a source of new economically important plants. The article begins by mentioning those who regarded the Amazon as a "desert made of trees" which needed to be removed, a view which, according to Schultes, was on the rise in the late 1970s. For him, there were countless reasons to preserve the Amazon. At the time, climate change was not widely known and is not even mentioned in his article. Schultes (1979) proposed only one reason for the maintenance of the forest, a fundamental reason for the future of the human species: "its incalculable value as an unexplored emporium of germplasm for new economic plants". Schultes demonstrates that the Amazon rainforest "should be considered as one of the most important origin centers of cultivated plants", in contrast to the parsimony of the contribution of North America, Australia, and most of Africa.

In his article, Schultes mentions the 1975 National Academy of Sciences report called "Underexploited Tropical Plants with Promising Economic Value". The report selects thirty-six species (out of more than 400) that should receive special attention because of their economic potential. One-third of these were from the Amazon. It is interesting to note the connection Schultes establishes between this diversity and forest dwellers; "Nowhere in the world", he writes, "have native peoples used such a wide variety of plants in the preparation of products, such as arrow and ichthyotoxin poisons. And several ethnic groups have an extensive pharmacopoeia of presumed medicinal plants. The use of hallucinogens and other narcotics and stimulants is widespread. Everything points to the fact that the Amazon's flora is a real, almost unlimited, chemical factory - and a chemical factory that is almost untouched, waiting for the attention of scientific research" (Schultes 1979: 264).

In the aforementioned 1975 American report, the contrast between the potential of unexplored plants in tropical regions and its almost nil economic use is attributed to the concentration of research around some already consolidated plants (National Academy of Sciences 1975). The report highlighted the potential of products for industry, human and animal feeding, and chemicals, that scientists were not studying. This was partly due to the scarcity of institutions around the world that trained people in tropical botany.

Nevertheless, it is important to highlight the immense research efforts located in the Amazon; this includes herbaria and research institutes working on the Amazon's biodiversity. Brazilian herbaria, for example, contain hundreds of thousands of specimens (approximately 247,000 at INPA-INCT, 230,000 at Museu Emilio Goeldi, and 200,000 at Embrapa Eastern Amazon), while the herbarium at the Amazonian Scientific Research Institute in Colombia provides a database of 100,000 plants (Mendoza-Cifuentes *et al.* 2018). Its ichthyological and aquatic macroinvertebrate collections are also of great importance. Samuel Almeida, a researcher at the Museu Paraense Emílio Goeldi, wrote "Plants of the Future of the Northern Region," and listed no less than 93 species about which there is a reasonable level of information (Vieira *et al.* 2011). A book by Clay *et al.* (1999) is also an important example of scientific knowledge of Amazonian biodiversity and opportunities for its use. Research by the Brazilian Agricultural Research Corporation (EMBRAPA) shows that there are more than 250 species of palm trees in Brazil, more than half of which are located in the Amazon. However, research tends to prioritize a dozen of these (Lopes *et al.* 2015). The result is that even contemporary pharmacopeia is focused on the use of a small number of plants, which contrasts with the richness of tropical biodiversity, and particularly Amazonian forests (Barlow et al. 2018). According to a 2017 Kew Royal Botanic Gardens report, less than 16% of the species used in plant-based medicine are officially regulated. The number of native plants in the Brazilian pharmacopeia fell from 196 in the 1926 edition to 32 in 1959 and only four in 1997 (Allkin *et al.* 2017).

Despite the work of several ethnobotanical museums in the region, the Amazon's contribution of local plants to medicines for official pharmaceutical uses is negligible. The Sacata Museum, in Macapá (Brazil), contains a Pharmacy of the Earth with raw materials produced by communities in the region. Such initiatives do not go beyond the strictly local scope. Currently, the only Amazonian product included in the Brazil Unified Health Service (SUS)'s list is "cat's claw" (*Uncaria tomentosa*), a species discovered by its use by Indigenous communities in Peru, and that has a wide distribution in all Amazonian countries (Valente 2006).

These are just a few examples that illustrate the paradoxical distance between the greatest socio-biodiversity on the planet and the low utilization of such diversity. It is clear that this scarcity cannot exclude the existence of an economy of forest socio-biodiversity throughout the entire Amazon, which has social and market structures that are part of the culinary, material, religious, and therapeutical options of its populations, and which is strongly supported by the knowledge of Indigenous peoples and local communities (see Chapters 10 and 13).

However, utilization of this wealth and the benefit it can bring to forest dwellers, adjacent urban populations, and the world, are far below their potential. A meta-analysis by Paletto *et al.* (2020:270) analyzed 225 documents on forest bioeconomy published by 567 organizations from 44 countries; the most represented countries were Finland and Canada. Of the ten organizations that have published the most in the area of forest bioeconomy, there are none located in a country with tropical forests. Of all the works analyzed in the article (indexed by Scopus), the keywords "bioeconomy" and "tropical forests" never appear together. While this does not mean the absence of research on the use of biodiversity in tropical forests, it shows the scarcity of cutting-edge applied science and technology in tropical forest regions.

The economic consequence of inadequate use of the Amazon's forest biodiversity is well expressed in the work of Coslovsky (2021), referring to Brazil; between January 2017 and December 2019, the nine states of the Brazilian Amazon exported 955 different products. Of these, 64 agricultural or forest products allowed an annual turnover of USD 300 million. However, in the global market for these products, the participation of the Brazilian Amazon is negligible, under 0.2% of the total. The Amazon is unable to compete with countries whose development indicators are more or less equivalent to its own, and occupies a negligible part of markets which, given its potential, its presence could be much greater (Coslovsky 2021).

In fact, exploitation of the Amazon's socio-biodiversity has remained practically the same since the colonial period. Oils from Andiroba (*Carapa guianensis* Aublet.; Souza *et al.* 2019) and Copaíba (*Copaifera* spp.), for example, are still conventionally extracted, generating low economic return. The wealth of fish in the Amazon is not supported by adequate industrialization and refrigeration, as further discussed below. One of the most important assumptions for the emergence of a new bioeconomy of healthy, standing forest and flowing rivers is that it should be supported by an ambitious industrial policy that is based on the expansion of socio-biodiversity knowledge, and that results in technological innovations that benefit Amazonian populations through its elaboration processes, and the entire world through its use. Without an industrial policy capable of stimulating entrepreneurial initiatives that surpass current forms of production and use of the forest and rivers, there is no way to make biodiversity the decisive vector for the sustainable development of the Amazon.

The objective of this chapter is to suggest pathways for public policies and actions, both for businesses and civil society, to favor the emergence of a bioeconomy that contributes to raising the levels of human development, expanding the use of its biodiversity, exploiting its multiplier potential, stimulating environmentally-sensitive infrastructure investments that meet peoples' needs, and strengthening the scientific and technological knowledge necessary for the forest socio-biodiversity economy to become the epicenter of the region's development and an economic matrix that favors the expansion of socio-biodiverse areas.

These pathways are not limited to the sustainable economic use of what forest areas can and do offer. It is paramount that the value chains that produce agricultural and mineral commodities transform, not only to entirely eliminate forest destruction, but also to use less impactful techniques and inputs on biodiversity within production systems. Attention should be directed not only to forest dwellers, but also to the thousands of family farmers in the region (see Chapter 15). Many of them produce conventional products (e.g., dairy and cassava), often in a way that is compatible with preserving a rich biodiversity. One of the major obstacles to expanding this diversity is the instability of markets interested in their products.

It is clear that a new bioeconomy of a healthy, standing forest and flowing rivers will only have a chance to fulfill its vocation if it also benefits the Amazon's urban populations. Strengthening the connection between rural and peri-urban areas, through urban markets where socio-biodiversity products are commercialized, or stimulating existing or new companies to improve and disseminate this wealth, are key strategies to be developed. It is also important to improve research that will allow the emergence of new products, and expand the potential of forest products in gastronomy. Cities will play a fundamental role in the emergence of a new, dynamic, and competitive forest bioeconomy.

The emergence of a dynamic bioeconomy capable of altering the institutional environment and economic practices that have contributed to the destruction of the Amazon requires participation not only of the economic actors that are potentially interested in its use, but mainly the participation of forest dwellers, family farmers, settlers, and urban populations in the Amazon. It is paramount that the value chains that produce agricultural and mineral commodities are also transformed, in the sense that their activities contribute to forest conservation and regeneration, biodiversity strengthening, and that their production processes are tracked, allowing them to expose their products to markets that are connected to the global conservation movement. There are existing tools for the transparency and accountability of value chains, aimed at eradicating deforestation and promoting sustainable practices. Examples include Global Forest Watch Pro (GFW Pro), Trase, and the Accountability Framework. The Trase platform has been contributing to the transparency of soy and beef production in the Amazon, linking impacts in production regions with the global markets (Trase 2020; zu Ermgassen *et al.* 2020). It is also important that public, private, or associative financial resources contribute to maintaining and regenerating ecosystem services, for example through different forms of payment for environmental services (PES), favoring the sustainable use of biodiversity and knowledge from both science and the people who have contributed to keeping the forest standing until now.

This transformation must also be stimulated by research and educational institutions. Bearing in mind, for example, the importance of improving livestock sustainability in the Amazon, it is essential to invest in different research topics that support the development and scaling-up of integrated systems, such as those for crops, livestock, and forests, as several initiatives across the region are already exploring (Garrett *et al.* 2020). In the same way, it is necessary to stimulate research that addresses not only monoculture plantations (e.g., eucalyptus, pine), but forest ecosystems and their biodiversity. These examples should be expanded, as there is an urgent need to fill gaps in the taxonomy of organisms and the living wealth of biodiversity in all strata of Amazon forests (i.e. from the floor to the canopy) (Plotkin 2020).

This chapter is divided into seven sections, in addition to this introduction. Section 30.2 seeks to characterize the bioeconomy as one of the most important values of contemporary socio-environmental thinking and, at the same time, its strategic value for Latin America, and particularly the Amazon, to occupy a relevant place on the frontier of global scientific and technological innovation. This section summarizes some of the established definitions of the bioeconomy. It is important to clarify that, given the characteristics of tropical forests, the option was to show bioeconomy as a highly diversified reality in terms of players, products, and services, which is presented in section 30.3. Section 30.4 describes the most important characteristics of the techniques and markets prevalent in the use of forest socio-biodiversity, focusing on timber and non-timber forest products (NTFPs), as well as in fisheries. Section 30.5 shows the importance and potential of three key services: forest regeneration, tourism, and PES. Section 30.6 analyzes the transition from what has hitherto been an economy based on the destruction of nature to one based on knowledge of nature, with an emphasis on the actors and organizations involved. Section 30.7 makes policy recommendations, and section 30.8 summarizes the main conclusions.

In addition to the bibliographic sources cited in the text, this chapter is based on a set of interviews with socio-environmental activists, entrepreneurs, scientists, and other stakeholders.

30.2 Bioeconomy: More than a Sector, an Ethical Imperative

There is no consensual definition of bioeconomy. Rather than select a particular definition, this chapter presents the diversity of visions and highlights guiding principles.

A 2020 report by the United States National Academies of Science, Engineering and Medicine defines the bioeconomy as "economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences". They calculate that the bioeconomy corresponds to 5.1% of North American Gross Domestic Product (GDP), including the agricultural sector as a whole, as well as biotechnology (NASEM 2020). Use of biological data in medicine, renewable biomass production for energy, bioengineering, and synthetic biology all contribute to the approximately US $1 trillion value of the US bioeconomy.

In the European Union, the link between the economic use of biological resources and important scientific achievements of the twenty-first century was important in understanding bioeconomy as a strategic sector for economic growth (Birner 2018).

Aguilar and Patermann (2020) emphasize two fundamental dimensions of the contemporary bioeconomy. The first brings it closer to the pioneering work of Romanian economist Georgescu-Roegen (Georgescu-Roegen 1977; Carpintero 2006), by insisting on the need for a holistic approach that goes beyond its sectoral dimension. According to this vision, the entire economic system is transformed, and its development depends on co-evolution between society and nature. Fücks (2015: 201) goes so far as to speak of a "mode of production powered by the sun". There is an important line of contemporary thinkers, of whom René Passet, Herman Daly, Kenneth Boulding, and Partha Dasgupta are among the most influential, whose work shows that economic activity depends on services provided to humanity by nature, and that the sustainable use of biodiversity has a decisive function (Boulding 1966; Daly 1996; Passet 1996; Dasgupta 2021).

The second dimension to which Aguilar and Patermann (2020) bring attention is that the destruction of biodiversity and, at the same time, the immense potential of scientific advances to improve social life, give space for the emergence of a new relationship between countries, which they call biodiplomacy. This is not about challenging the sovereignty of each country over its respective territories and the legitimacy of conventional diplomacy, which turns primarily to the defense of national interests; this defense does not overlap with a "global and integrated approach to the management of global challenges that affect the biosphere" (p. 24).

European documents, discussions preceding the Convention on Biological Diversity (CBD), and academic contributions show that, much more than an economic sector, the bioeconomy can and should be considered as an ethical-normative imperative, i.e., as a value. Its economic importance is growing, but, at the same time, the European definition, which links bioeconomy to the circular economy, emphasizes that the bioeconomy is an essential component in achieving the goal that, in 2050, to use the CBD's expression, humanity will live in harmony with nature (CBD 2020).

In Latin America, many countries assimilate parts of the European or North American definitions. However, appropriate adaptations need to be made to regional socioeconomic and environmental contexts. A more socioecological vision (NASEM 2020) is vital for Amazonian countries to conserve their rich biodiversity and value the peoples that promote it. It is time to establish these visions since bioeconomy initiatives are emerging and national bioeconomy policies are being developed (e.g., Sasson and Malpica 2017; Lopez-Hernandez and Schanz 2019), as discussed below.

30.2.1 Why a new bioeconomy of healthy standing forests and rivers flowing?

Addressing the bioeconomy as a value in the case of tropical forests (and particularly the Amazon) means that economic activities, despite their wide variety of sectors, players, and technical resources, must always result in the strengthening of forest socio-biodiversity and in the improvement of living conditions of rural, peri-urban, and urban populations inhabiting the territory. It is about uniting what has been, until now, separated; improving the living conditions of its population, not through the destruction of nature, but through knowledge of it.

The idea of a new bioeconomy of healthy, standing forests and flowing rivers is therefore not rhetorical. The contemporary bioeconomy will increasingly rely on ethical and normative precepts directed to the transformation of society toward sustainable development pathways. This achievement should be supported by science and technology in order to repair the current destructive relations between society and nature. Unfortunately, the fact is that the translation of these values into practice is in its infancy in tropical forest regions.

One of the most surprising findings is the scarcity of references to tropical forests and the Amazon in scientific and technological literature on the contemporary bioeconomy. As previously highlighted, recent publications on botanical economics are fertile in pointing out the potential of the Amazon for a bioeconomy. However, poor practical implementation of this potential is shocking when one takes into account that this territory has the greatest biodiversity on the planet. The vast literature on Neglected and Underutilized Species (NUS) (Padulosi *et al*. 2019; Antonelli *et al.* 2020) expresses well the gap between the richness of biodiversity and the precariousness of its economic use.

This chasm is explained, first of all, by the unprecedented challenge represented by the sustainable use of the tropical forest, based on the knowledge economy, as already pointed out in an important document from the Brazilian Academy of Sciences (ABC 2008). In temperate countries, the bioeconomy is based on the strength of laboratories, planted crops, and very homogeneous forests. It includes the production of bioenergy, biomaterials, and resins, achievements often derived from the use of digital technologies to obtain molecules that are useful in the production of medicines. Also, new production techniques allow reduced use of pesticides and chemical fertilizers in agriculture, and new forms of animal feeding. These components of the bioeconomy arise in environments whose biological diversity is much less complex than that of tropical forests.

Harnessing the potential of tropical forests without destroying them, converting their regeneration into an economic growth engine, combining scientific knowledge with the knowledge systems of forest and river dwellers, and transforming the production and commercialization of commodities in a way that they can be integrated into the strengthening of Amazonian ecosystems, are some of the most important challenges encountered by a new bioeconomy of healthy, standing forests and flowing rivers. Until now, overcoming this challenge in the Amazon has been unsatisfactory.

A recent survey on bioeconomies around world shows that among the countries of the Amazon only Brazil, Colombia, and Ecuador have bioeconomic policies (German Bioeconomy Council 2018). Still, as is clear from a recently-released document by the National Confederation of Industry in Brazil (CNI 2020), these policies convey no strategy for an economy of forest socio-biodiversity to emerge in the Amazon. Likewise, a recent publication on bioeconomy in Latin America and the Caribbean from the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) cites the Amazon only once and focuses on what crops planted on the continent can offer (Rodríguez *et al.* 2019). In the important book on the bioeconomy organized by Lewandowski (2018), tropical forests are mentioned in only one section and there is only one quote about the Amazon.

The forest and associated ecosystems are recognized as a provider of ecosystem services but not as a territory in which contemporary scientific and technological achievements can represent a path for development. There is a gap between the richness of the ecosystems and the current ways of utilizing them.

30.2.2 Bioeconomy: A path to Scientific and Technological Innovation

Filling this gap is not only a matter of interest to those who live in the Amazon. A new bioeconomy of healthy, standing forests and flowing rivers offers a strategic pathway to bridge the gap that separates the Latin America of today from the global scientific and technological innovation frontier (IDB 2010). At the beginning of the 1980s, Latin America's industrial capacity was competitive on the world stage. Since then, the continent has gone through a process of re-primarization, which some authors do not hesitate to call neo-extractivism (Gudynas 2021; see also Chapter 14). The Harvard University Atlas of Economic Complexity (Haussman *et al.* 2013) shows that the density of Latin America's insertion in the global economy is marked by a low incorporation of knowledge, information, and intelligence. This is not to underestimate the importance of scientific and technological advances in Latin American agriculture–although these advances have been occurring far from the Amazon—but these results are not sufficient to bring the continent closer to the global frontier of scientific and technological innovation. Perez (2015), one of the most important researchers on technological revolutions of the modern era, advocates for a pattern of economic growth supported by natural resources. Her justification is that the prospects for the continent to assert itself as a significant exporter of televisions, automobiles, or microchips are low, since it has accumulated a delay in those areas that will not be overcome in the short term. It is in its natural resources and, above all, in the application of science and technology to sustainable management, processing, and pharmaceutical discoveries embedded in biodiversity, that Latin America finds its greatest chances to move from an economy whose international insertion is based on commodities, towards a pattern in which biodiversity products, based on the knowledge economy, gain increasing national and international importance. In fact, the greatest chance to reposition Latin America from a commodity-based economy toward a nature-based one is through the conservation of its natural resources and, above all, the application of science and technology. They are essential to promote sustainable management, processing, and pharmaceutical discoveries embedded in biodiversity and, ultimately, increasing national and international importance. This strategy should be followed to realize the ambition for the Amazon to become a contemporary bioeconomy. However, for a new economy of healthy, standing forests and flowing rivers to emerge in the Amazon, it is necessary to first compile a summary of the main current characteristics of the economic use of forest socio-biodiversity. This is the theme of the next section of this chapter.

30.3 Diversity, the Key Feature of the Amazonian Bioeconomy

Diversity is the most important feature of the current forest socio-biodiversity economy in the Amazon. This refers not only to the extraordinary and still highly unknown biological wealth of the region (see Chapter 3), but also to the variety of relations established between human populations and this biodiversity (see Chapters 10 and 13). Approximately two-thirds of the pan-Amazon's inhabitants live in urban areas. At the same time, the organization of these urban centers might differ from that of traditional, with different types of buildings and transportation networks, related to the close relationship of residents with the forest and family farming areas (see Chapter 14). Furthermore, as discussed in section 30.7, countries such as Brazil underestimate the demographic importance of its rural population, owing to the blurred boundaries between rural and urban areas.

During the process of occupation of the Amazon, family farming resulting from spontaneous migration, directed colonization, or settlements was very important; more than 700,000 family farmers live in municipalities within the Brazilian Legal Amazon alone (IBGE 2019). Although many incorporate elements of the polyculture tradition typical of forest populations into their production practices, the need for income generation often leads farmers to expand livestock areas, to the detriment of biodiversity (see Chapter 15).

Large farms also need to be considered, especially since land ownership concentration in the Amazon has been increasing in recent years, especially in Brazil (Romeiro *et al.* 2020). Although there are examples of farms that seek to regenerate previously deforested areas, there are large territorial units where deforestation is very high. Furthermore, this deforestation is linked to institutional degradation and violence; Sant'Anna and Young (2010) demonstrate increased homicide rates municipalities with greater deforestation in the Brazilian Amazon.

One of the most comprehensive analytical frameworks on the bioeconomy in the Amazon was produced by *Concertação pela Amazônia* ("Accord on the Amazon"), a network of individuals, organizations, and companies created in 2020. It represents an effort to develop proposals not only to stop violence and destruction but also to address the emergence of a strong and competitive socio-biodiversity economy in the region. This organization states an elementary but decisive finding: the extent of the territory, national traditions, varied ethnic compositions, languages, national legislation, and institutions of the Amazon should always be presented in their plurality (Concertação pela Amazônia 2021). Diversity is the key feature, asset, and challenge for the region.

Despite being developed within the scope of the Brazilian Amazon, the work of the *Concertação* is illustrative of a more general picture. Within the Amazon, there are "conserved regions" (where conserved forests dominate), the "arc of deforestation" (presenting extensive open areas and a few forest remnants, which have been degraded by logging and forest fires), "anthropized regions of converted forests" (usually associated with areas opened by productive activities), and "cities". Each of these regions can be characterized by its predominant activity and also by a specific proposed development agenda.

Even the areas with a predominance of trees are varied, as shown in Figure 30.1. This diversification ranges from conserved forest areas to native or exotic monocultures, passing through silvicultural enrichment of degraded forests, restoration of open areas, and the planting of long-cycle exotic species.

It is within Amazonian diversity and its forest continuum that Concertação classifies the current bioeconomy into three fundamental types. These types are what can truly be defined as the bioeconomy of the Amazon, with a clear difference between this bioeconomy and that described in international literature, which is not supported by such a rich and complex socio-biodiversity. It is important to note that none of these types exist in a pure state and that they serve primarily as a heuristic resource to describe the socio-biodiversity that marks the current use of the forest.

First, there is the traditional bioeconomy based on the biodiversity of native ecosystems. Its predominant activities are of an extractivist nature and carried out for self-consumption, commercialization with consolidated intermediaries (see below), and unprecedented commercial circuits linked to fair trade. The products derived from these activities hardly reach large volumes and only reach markets as niche products. Precisely because of the biodiversity richness on which these activities are based, they may gain importance for the pharmacological, cosmetic, and cutting-edge biotechnology segments. Strengthening businesses linked to this biodiversity is especially difficult, not only due to dependence on incomplete and imperfect markets, but also the regulation of access to benefits obtained with the use of biodiversity.

The second type of bioeconomy is based on forest management, and is suitable for regions where forests have undergone some type of disturbance or degradation (e.g., selective logging or fire). In the previous type, biodiversity is inherent to the activity; here production systems can be more or less diverse. There is a significant commitment from public and private organizations to implement agroforestry systems (AFS), including the Integration of Crop, Livestock and Forests (ILPF). In these regions, it is also important to identify priority areas to be restored for the provision of ecosystem services such as water and crop pollination.

The third type is the commodities bioeconomy. It may be surprising that agricultural and mineral commodities are included in this typological description, but this is justified for two reasons; 1) be-

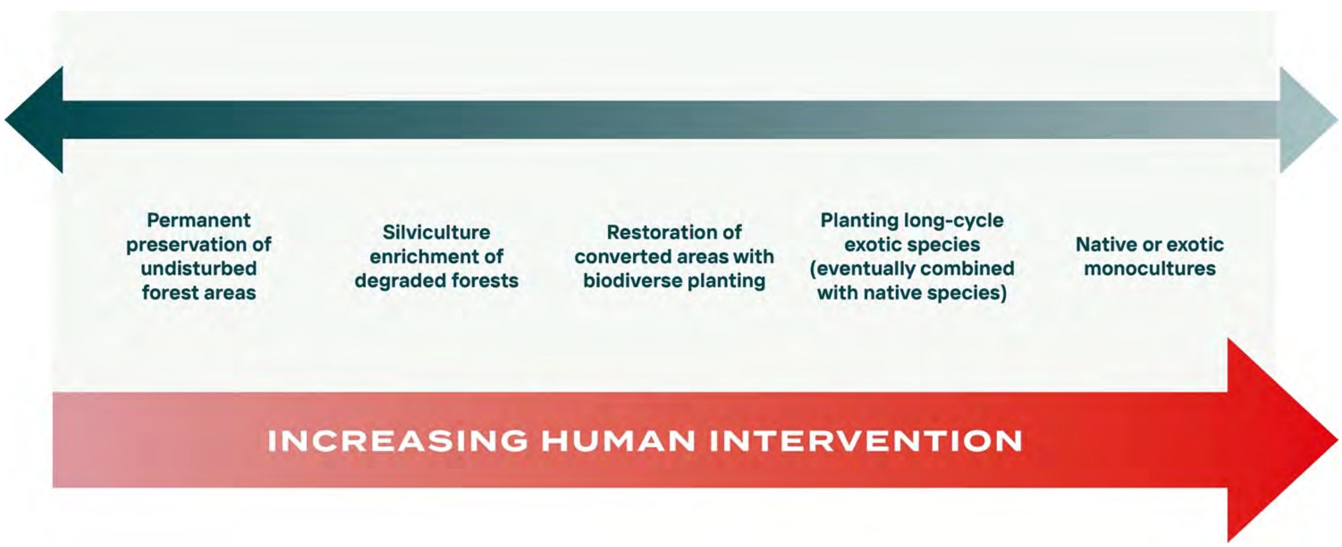


Figure 30.1 Continuum of human interventions on forest ecosystems varying on conservation status. Adapted from Concertação pela Amazônia 2021.

cause of the impacts (so far, almost always destructive) that these forms of production have on biodiversity and ecosystem properties; and 2) given the large area that commodity production currently occupies in the Amazon, it is urgent that the areas directly and indirectly affected by them are also subject to regenerative processes capable of making their high yields compatible with the protection of terrestrial and aquatic ecosystems at landscape and regional scales. This involves not only the conservation of forest areas within agricultural properties and across landscapes, but also techniques that reduce the use of chemical inputs in agriculture (e.g., pesticides), avoid pollution by mining and agricultural activities, and that promote the emergence of innovative production systems.

The challenge of regenerative agriculture and livestock is not limited to large farms but also involves family farming and the different forms of land use in the Amazon. It is not uncommon, for example, for the production of small animals or freshwater fish to be dependent on extensive grain cultivation, whereas underutilized products from the region itself could meet this need. Agrarian systems in the planet's most biodiverse region cannot support its prosperity with techniques that threaten biodiversity and do not make use of its potential. This justifies the ambition that the supply of commodities in the Amazon be guided by the values of a bioeconomy.

The three segments above are presented based on assets and, especially, problems that need to be overcome for the emergence of a new bioeconomy. Moreover, precisely because it is a transition process, it is important to start by understanding the main features of the current economic use of the Amazon's socio-biodiversity.

The next section presents three sectors in more detail to underline some of the challenges presented above: timber, non-timber forest products, and fishing/pisciculture. Commodities are not analyzed here, since their impacts have already been studied in previous chapters (see Chapters 14, 15, and 17). However, it is essential that their production is compatible with the protection and regeneration of biodiversity within the properties and landscapes in which they are developed.

Finally, strengthening socio-biodiversity pillars in economic activities must emerge within the scope of a circular bioeconomy. One of the most severe consequences of the economic success of açaí (*Euterpe oleracea*) (see below) is an increase in waste without an appropriate destination. In Belém alone (State of Pará, Brazil), 16,000 tons of waste are produced daily. A proposal by IDESAM to produce fiber ecopanels from this waste illustrates the fundamental link between the sustainable use of biodiversity products and the circular economy, as pointed out by Schroeder (2019).

30.4 The Current Limited Economy of Forest Socio-biodiversity

The destruction of the largest tropical forest on the planet affects the Amazon as a whole, as seen in previous chapters. No country has deforested a great area than Brazil (Smith *et al.* 2021; see also Chapter 19). The Brazilian Amazon accounts for 9% of the country's GDP (Amazônia Legal em Dados 2021), but deforestation in the region (classified as land-use change) contributed to approximately 38% of Brazilian greenhouse gas (GHG) emissions in 2019, as inferred by Albuquerque *et al*. (2020).

Given its size and diversity, it is important to note that destructive forms of use and occupation in the Amazon do not occur everywhere. Indigenous territories (ITs) and protected areas (PAs) share a small proportion of the area deforested (13%), while covering more than half of the region's forests (see Chapter 16). The demarcation of territories belonging to Indigenous, *quilombolas*, and *ribeirinhos* peoples is a fundamental democratic achievement (Abramovay 2020a). Deforestation rates inside ITs are one half to one third that of unprotected areas with access to markets in Bolivia, Brazil, and Colombia (Ding *et al.* 2016).

The territories of Indigenous peoples and *quilombolas* contain one-third of all carbon stored in forests in Latin America, and more carbon than all the forests of the Democratic Republic of Congo and Indonesia combined (the two countries with the largest forest areas in the world after Brazil, FAO and FILAC 2021).

Some of these territories collectively manage forest resources, as discussed below. The harvesting of non-timber forest products is also important in these areas, as demonstrated by the Origens Brazil Seal, which certifies forest products meeting fair trade principles (Origens Brasil 2021).

Outside of protected areas, the collection of açaí, both in Bolivia and in Brazil, has consistently increased the income of thousands of families, having important multiplier effects on urban occupations (Costa 2020). A study by Lopes *et al.* (2018) shows that, unlike the overwhelming majority of extractivist products, income from açaí production is competitive with cattle production. Other studies have shown that açaí produced in agroforestry systems has even higher returns than soy on a per hectare basis (see Chapter 15). An important fraction of the product comes from areas endowed with rich biodiversity, inspired by the practices of traditional communities in the Amazon, as shown by the publications of Brondízio (2021), de Costa (2020), and Homma *et al.* (2006). Given rising demands, both in Latin American and globally, the production value and supply have been increasing. Açaí has the most advanced industry relative to the other current products extracted from the region, and this includes not only to juice, but also other açaí products (e.g., oil, ice cream).

Food safety is a concern; the consumption of fresh açaí pulp contaminated by the protozoan *Tripanosoma cruzi* has caused outbreaks of Chagas disease in some cities in the state of Pará (Brazil). This is easily prevented by processing açaí using sanitary techniques (de Oliveira *et al.* 2019). However, further scientific research and public measures are needed to completely solve this issue.

Açaí has anti-inflammatory properties (Machado *et al.* 2019) and an immense potential for prostate cancer treatment (Jobim *et al.* 2019). However, without an industrial policy aimed at long-term financing for research and an environment that supports innovation, it is highly unlikely for these potentials to be realized.

As discussed in section 30.6, the broad mobilization of the business sector to transform agricultural production to be compatible with conservation is a recent but significant trend, especially in Brazil. The company Sambazon has reached markets in Europe and the United States using a business model that meets demand for highly nutritious, organic, socially- and environmentally-responsible products (Tunçer and Schroder 2010).

However, these initiatives cannot disguise the prevailing conditions in the region, marked not only by technical limitations, an almost complete absence of industrial processing, and obstacles in achieving minimum health and safety standards required by key export markets (Valli *et al.* 2018); but also by forest dwellers' dependence on incomplete and imperfect markets characterized by strong clientelism and power imbalances. Historical legacies and systems such as *aviamento* and *regatão* persist and prevent the development of a strong and competitive bioeconomy. *Aviamento* is a system in which workers' debts to those who provide them with basic goods result in personal dependency that can lead to modern slavery (Guillen 2007). *Regatão* is a bartering system where goods from cities are brought to rural areas to be traded (often at unfair rates) for locally-produced agriculture and forest products (McGrath 1999).

These economic activities lead not only to permanent tax evasion, but, above all, to a market structure that does not favor quality, supply regularity, and innovation. Another critical challenge is the lack of access to information about commodity prices. A small group of players are involved in systems rooted in clientelist domination and who control the purchase of commodities produced in rural areas and sold to processors.

Figure 30.2 Açaí. Photo: Embrapa/Ronaldo Rosa.

30.4.1 Timber and Wood

The tropical timber market in the Brazilian Amazon has declined sharply in the past two decades, with native wood supply decreasing from 10.8 million m^3 in 1998 to 6.2 million m^3 in 2018. Similar to other extractive products (e.g., rubber), wood of Amazonian origin is being replaced in civil construction by wood from monoculture plantations, plastic, steel, and aluminum (Lentini *et al.* 2020).

In the "arc of deforestation" of the Brazilian Amazon, the capacity for timber extraction has been depleted by the forestry sector, causing producers to seek new areas to harvest. This displacement pattern "occurred because the forestry industry in the Amazon remains essentially the same with regard to the continued need to explore new forests to guarantee its long-term survival, due to the slow progress observed in the adoption of large-scale sustainable management" (Lentini *et al.* 2020).

Wood processing is also inefficient, with only 41% extracted wood processed. Of this, 72% corresponds to sawn wood, which has low added value (Gomes *et al*. 2012). The furniture industry, the sector with the highest added value in the Amazon, has been losing competitive capacity in terms of the number of companies, jobs, and participation in exports.

Corruption and predatory practices are perhaps no surprise given the high levels of illegality that dominate the timber sector (see Chapter 14), outweighing legal sales by many times. For example, in the Brazilian state of Pará, a study found that, between 2017 and 2018, 70% of timber was harvested illegally (Cardoso and Souza-Junior 2020). Legal, sustainable timber production can hardly compete with what some call "forest mining" (Bryant *et al.* 1997). Illegality also marks logging in other countries, such as Colombia (EIA 2019) and Peru, as shown in a study conducted by the Center for International Forestry Research (CIFOR) (Mejía *et al.* 2015).

The predominance of illegality and unsustainable techniques is not due to a lack of knowledge regarding sustainable management of tropical wood. This knowledge exists, and there are many communities that apply it correctly. Proper forest management consists of removing only what can be recovered in a given time period (Brazilian legislation recommends approximately 35 years, varying with the volume harvested). It is necessary to calculate how much can be cut (and removed from the forest, which involves detailed logistics) so that, a few decades later, regeneration can take place. While this research was nascent in the 1990s, today it has matured and is being applied appropriately by several forest communities across Latin America in of projects developed by EMBRAPA (Santos *et al*. 2021), IMAZON, Instituto Floresta Tropical (IFT 2021), and others.

Evidence shows that forest policies in different countries need to be reassessed. The use of a few dozen species and current management norms (cycle length, harvest, intensity) prevent the recovery of wood stocks and, ultimately, the sustainability of the timber sector (Piponiot *et al.* 2019). Bioeconomic development in the wood sector involves *inter-alia* expanding the range of managed species, adapting management regulations, and modernizing industrial processes in order to allow the full regeneration of forests.

Given current declines in demand for wood from tropical forests (it is important to note plantations supply approximately 90% of the wood in Brazil, according to IBGE [Schmid 2019]), and the increase in technical knowledge, this sector could provide income and decent work on a considerable scale.

One main challenge that illegal harvesting can operate at far lower cost than more technically advanced units which respect environment and labor laws. In addition, the lack of defined property rights discourages long-term investment in sustainable projects. Poor management of illegal harvesting operations and the outdated technologies used also prevent selective removal and leads to large-scale destruction (Brancalion *et al.* 2018). The contrast between this and the more advanced contemporary forms of management (and whose costs tend to reduce in the future) is striking. Global initiatives such as the smart tree grid, which uses digital devices to scan millions of trees and detect key information to assess their resilience, are important in this aspect (Peskett 2020). In addition, our interviews with individuals from this sector show that complex procedures for obtaining logging authorizations discourage sustainable projects.

Finally, the added value of timber production in the Amazon has regressed over the past 20 years. The volume of raw sawn wood increased by 20% between 1998 and 2018, while products with higher added value (e.g., slabs, plywood) decreased by the same proportion (Lentini *et al.* 2020). It is also important to note that the wood species exploited today constitute a small fraction of the hundreds of species with potential in the region, resulting in underutilization of raw material and lost opportunities. Further research and investments are fundamental to realize the potential of new species in the market.

The adoption of technological innovations to increase efficiency in wood processing requires investment in fixed capital with a long maturity period. This only makes economic sense if there is a guaranteed long-term supply of wood in areas close to processing units, which is antagonistic with the predatory extraction model commonly practiced that quickly depletes local reserves. As a consequence, there is little investment in technological improvement, as sawmills and processing units need to be mobile and move along the deforestation frontier. For this reason, guaranteeing land property rights, including public areas and Indigenous peoples and local communities (IPLCs)' territories, is essential to ensuring long-term contracts for raw materials that make the investment in technological improvements, in addition to enabling forest certification, a necessary condition to reach buyer markets with greater added value (MacQueen *et al.* 2003).

Tropical forests have great potential to produce "noble wood", or high-quality, attractive wood for use in furniture, cabinetry, and other decorative uses. There are limited substitutions for such products, as neither plantations nor alternative materials offer similar quality and properties. There are two socially-constructive ways to realize this potential. The first is through collective management by forest dwellers, the main custodians of carbon stored in tropical forests. The opportunities for community forest management are vast in the Amazon, as approximately 50% of its area is occupied by a network of more than 6,000 ITs and PAs (see Chapter 16). IPLCs' surveillance over their territories is essential to preserve forest stocks and guarantee long-term management. Ensuring the legal land rights of these communities, including demarcation of territories (e.g., extractive reserves, Indigenous territories), is economically beneficial, as local communities take the best care of their own common goods using various forms of collective management (Romanelli and Boschi 2019).

Today, hundreds of communities generate income and jobs based on forest management. In some cases, their activities include the production of resins and other non-wood products, as well as tourism.

In Bolivia in 2013, 16 Communal Lands of Origin (TCOs) and 10 Indigenous lands held 111 approved management plans, covering approximately 1.8 million hectares and an annual allowable cut (AAC) of over 800,000 m^3. Approximately 300,000 m^3 (or 35%) of the AAC is harvested, generating approximately USD 7.5 million in gross income and benefiting approximately 6,000 Indigenous households (AFIN 2014; Del Gatto *et al.* 2018).

In addition to communal forest management, forest concessions are also an important path for the sustainable use of public areas, today threatened by illegal invasions and land grabbing. These mechanisms are applied especially in Peru and Brazil, although they are still far below their potential (Karsenty *et al.* 2008). In forest concessions in the Brazilian Amazon, in conservation units specifically designated for sustainable forest management (National Forests, State Forests for commercial exploitation, Extractive Reserves and Sustainable Development Reserves for communal exploitation), there is an annual extraction potential of 2–7 million m^3 of wood (Pereira *et al.* 2018).

There is an additional opportunity to develop a sustainable bioeconomy based on the beauty and diversity of tropical hardwoods in Amazon forests. The transition zone between the Andean and Amazon forest biomes in Colombia, Ecuador, Peru, and Bolivia (known as the "*piedemonte*" or "*ceja de selva*") contains a very large diversity of tropical hardwoods and timber species. Demand for tropical wood products is projected to increase in the coming decades (ITTO 2019); therefore, it is desirable to invest in large-scale AFS and forest enrichment systems to produce high-quality hardwoods in a relatively short time (20–25 years), which can be sustainably developed on existing deforested or degraded land, as extensively tested in the Colombian Amazon (Barrera *et al.* 2017). It is possible to combine sustainable, profitable timber production with ecological restoration, reduction of forest fragmentation, and recovery of ecosystem services, in addition to maintaining forest biodiversity and ecotourism potential.

The development of a strong forest socio-biodiversity economy based on the sustainable harvesting of wood faces four fundamental challenges. The first is linked to dominant, destructive forms of land use, with the opening of clandestine roads in Indigenous territories and protected areas. Efforts to contain illegality through strict legal and administrative rules have inhibited legal operations, by increasing costs and making them unable to compete against informal and criminal activities. The solution is obviously not the relinquishment of clear rules for logging, but the repression of illegal activities throughout the production chain and the formation of public and technical professional organizations capable of stimulating (and not restraining) legal activities.

The second challenge is to change wood management dynamics, which are currently concentrated on a few species with high-commercial value, aiming to maximize profits until their local populations become extinct (Richardson and Peres 2016). Mahogany (*Swietenia macrophylla*) and rosewood (*Aniba rosaeodora*) are emblematic examples of highly-valued species that became endangered and were then subject to trade regulations (IUCN 2021; CITES 2021; Salazar 2011; Grogran and Barreto 2005). Instead, the balanced use of hundreds of species needs to be encouraged; this requires investment and innovation in harnessing, processing, and adding value. Investments need to be channeled into the modernization of equipment, revenue, and production processes, as well as marketing for new species and products. The industrialization and commercialization of monocultures of native paricá (*Schizolobium amazonicum*) used for high-quality reconstituted wood panels (Medium Density Board, or MDF) in Paragominas, Pará, is an example (FLORAPLAC 2020). However, there are serious problems, both in terms of standardization in the cultivation of plants of this species (some individuals thicken, others remain stunted), and phytosanitary issues. Consequently, people involved in reforestation often prefer to use eucalyptus, an exotic species, over paricá, demonstrating the urgency for investments in the domestication of native species.

The third challenge is to connect logging with local demand (in the Amazon itself) through qualitative transformation. Various inputs for civil construction and the shipping industry, for example, can be replaced by wood from the Amazon, as shown by the Center for Management and Strategic Studies (CGEE 2009).

The fourth challenge is forestry legislation, which presents a fundamental contradiction. On the one hand, enforcement is deficient and fails to prevent illegal practices. On the other hand, as shown by Hirakuri (2003), still valid for the present times, the administrative procedures for legal logging are so complex that they discourage sustainable use.

30.4.2 Non-timber Forest Products

Currently, only a few non-timber forest products contribute to a forest socio-biodiversity economy and generate significant production, income, and jobs. While the role of non-timber forest products, such as medicinal plants, construction materials, and raw materials for handicrafts, is increasingly recognized, their commercialization is still in its early stage, as shown by Meinhold and Darr (2019).

This situation highlights one of the most important challenges for the emergence of a new bioeconomy of standing forests and flowing rivers. On the one hand, it is essential to preserve and strengthen forest and aquatic socio-biodiversity. At the same time, without the domestication and improvement of products such as cinchona (*Cinchona* sp.), cacao (*Theobroma cacao* L.), cupuaçu (*Theobroma grandiflorum*), bacuri (*Platonia insignis*), and uxi (*Endopleura uxi)*, the economic exploitation of biodiversity would be even smaller than it is today. Strengthening research aimed at domesticating economically-viable species within forest and aquatic systems (ecosystem services derived from their socio-biodiversity) is a critical need and could contribute to income generation and productive patterns adapted to the Amazon, supporting hundreds of thousands of farmers in the region.

What is at stake is the multifunctional nature of rural spaces on the lands of family farmers, Indigenous peoples, and local communities. Here, specialization rarely promotes monocultures, as is the case in other regions of the continent; rather, Amazonian traditional practices combine agricultural systems with extractivist management. In the Bailique Archipelago, located at the mouth of the Amazon River, for example, the açaí agroforestry production system was recognized as a good practice in Traditional Agricultural Systems (SAT), and received an award from the Brazilian Development Bank (BNDES) in 2019. In this system, common in the estuarine floodplain region of the Amazon River, *açaizais* and swiddens are mixed with a diversity of annual or permanent crops, forming a mosaic of high-value landscapes of agricultural, forest, and aquaculture heritage (Euler *et al*. 2019). In its 2018 and 2019 editions, the SAT BNDES Award recognized 53 good practice initiatives for the safeguarding and dynamic conservation of SATs in the Brazilian territory, of which 16 are communities in the Amazon.

The work of research institutions on expanding knowledge and improving diversified systems is essential. Agronomic research shows that systems are just as important as cultivars and, in a region such as the Amazon, the combination of scientific and traditional methods is especially important. Rather than produce a single commodity with high acceptance and market value, systems based on an immense variety of plants can have higher yields and returns. An interesting example is that of the Oiapoque Indigenous communities. They produce açaí (with EMBRAPA's support) using good practices, such as enriching their gardens with high-agronomic quality, pest-free banana and citrus seedlings. The result is an increase in production and supply to urban populations, both at markets and by direct sales, of diversified Indigenous products (flour, gum, tapioca, pepper, tucupi, chicory, manioc, banana, cane, piquiá, lime, tucumã, cupuaçu, taperabá), in addition to açaí.

According to vegetable and forestry production data (*Produção da Extração Vegetal e da Silvicultura*, PEVS) (IBGE 2019), Brazilian production is strongly concentrated in the Amazon, and a significant heterogeneity of contexts can be observed. Açaí stands out positively, with an increase in its production value from BRL 220.3 million in 2010 to BRL 539.8 million in 2016, indicating increased demand was compatible with growth in supply capacity. As previously highlighted, açaí has helped generate wealth and enrich the multifunctionality of spaces in many rural areas through cultivation that supports rich agricultural and forest diversity (Lopes *et al*. 2019).

The case of Brazil nuts (*Bertholletia excelsa*) goes in the opposite direction. The Brazil nut is one of the three most recognized food products derived from the Amazon. Its global value chain is worth almost USD 450 million annually. In Brazil, 60,000 extractivist families, organized in several small communal businesses, make the country the largest producer in the world, at 33,000 tons/year (TRIDGE 2020). Nevertheless, Brazil has been losing ground in international trade, currently dominated by informality (Brazil 2020a). In addition, the overwhelming majority of goods do not comply with basic technological and sanitary processes, which means that Brazil nuts are subject to special requirements for export to the European Union, due to the potential presence of aflatoxin. The consequence is that Brazil, unlike Bolivia and Peru, is unable to realize its full potential revenue.

Figure 30.3 Brazil nuts and seedlings in the background. Photo: Embrapa/Ronaldo Rosa

In Bolivia, degrading forms of labor exploitation have marked the commercialization of nuts. The "*habilito*" (advanced payment for work, which promotes a cyclical system of indebtedness) and the "*enganche*" (a type of debt slavery) are still widespread in the country. These systems are similar to the "*aviamento*" explained above. Inadequate markets and degrading work are an "obstacle to improve and generate a positive social impact in the utilization of nuts" (Gonzales Rocabado and Terán Valenzuela 2012).

Guarana is an important symbol of the Amazon for Brazilians, and the source of one of the nation's most popular soft drinks. Although it is an Amazonian product, nowadays production is mostly in the State of Bahia. Two initiatives from research institutes in the State of Amazonas are worth mentioning. The first, from the Institute of Agricultural and Forestry Development of the State of Amazonas (IDAM), involves 200 communities in the municipality of Maués and 80 communities in the Saterê-Mawé Indigenous Reserve, using new technologies to increase production and productivity (IDAM 2019). The second comes from the Secretariat of Science and Technology of Amazonas, which, together with other research institutions, executes the Inova SocioBio project, aimed at reducing information asymmetry in the value chain in order to improve knowledge and strengthen the production chain. *Waranê* (native *guaraná*) and *waraná* bread (*guaraná* stick) received the first Geographical Indication (GI) granted to an Indigenous people in Brazil. Native *guaraná* contains active ingredients and *guaraína* (caffeine from *guaraná*) in much greater proportions than *guaraná* produced in Bahia (Algarve *et al.* 2019). These distinctions are part of what an industrial policy aimed at sustainable valuation of socio-biodiversity should consider.

The examples above show how fundamental it is to expand studies on Amazonian fruit trees (Shanley and Medina 2005). In 1972, a book by Paulo Cavalcante (2010), listed no less than 163 edible fruits found in the Amazon, of which half were native fruit trees. Alfredo Homma (2016) celebrates this diversity, but laments "the scarcity of survey data

Figure 30.4 Guaraná in Altamira, Pará. Photo: Ronaldo Rosa/Embrapa.

in relation to native and exotic fruit trees, vegetables and ornamental plants", and that "the apple is found even in the furthest corners of the Amazon and at a lower price than that of native fruits". Despite the region's immense biodiversity, three-quarters of wholesale fruit and vegetables traded in Belém come from other states in Brazil (Homma 2016b). Nevertheless, it is not simple to harness this potential; most of these fruits rot quickly, have dispersed distribution, and/or have multiple harvesting times and processing systems, which hinders their commercialization.

The extraction of natural rubber in the Amazon also shows a sharp decline; production fell by more than half between 2010 (4,000 tons/year) and 2016 (1,200 tons/year), and there was an even more substantial reduction in production value, falling from BRL 17.3 million to BRL 4.2 million in the same period (Pereira *et al.* 2018).

The market for vegetable oils derived from forest species (andiroba, babaçu, coconut, almond, copaiba, cumarú, murumuru, ucuúba, and tucumã) is booming. Although official data does not yet fully cover these products, which play an important role in the diversification of production and income, an estimated 45,751 extractivist families are engaged, generating approximately BRL 50 million in raw materials sales per year (IBGE 2019).

For the most part, oil production faces technical limitations, low added value (Villa Nova 2020), and compromised capacity to generate income because of the market structure in which they operate. As highlighted by Meinhold and Darr (2019), the value chains of these products rarely allow them to become the basis of a promising process of income generation. Their value chains are marked by "limited market information available, poor infrastructure and financial constraints", and also by the fact that "middlemen may sometimes be the only pathway for producers to access markets". Information asymmetry between buyers and sellers is the trademark of these value chains, often resulting in prices below production costs. An econometric study conducted by Angelo *et al*. (2018) demonstrated low price elasticity in relation to demand, which is a clear sign of incomplete and imperfect markets.

The predominance of certain market structures in the Amazon are longstanding, in which the sellers of extractive products historically depend on a single buyer, who is also the one responsible for selling them the goods necessary for their subsistence. The extra-economic components involved in this relationship are very strong, as clearly described by Gonzales Rocabaldo and Terán Valenzuela (2012) when referring to the "*habilito*". In the second half of the eighteenth century, an "Amazonian *caboclo* peasantry" already existed, which engaged in the trade structure led by *regatões* (mobile merchants) and large '*aviadores*' (suppliers, financiers), and which connected the Amazon to international drug market (Costa 2020).

The predominance of these market structures over time is impressive. Extensive work conducted by Meira (2008) in the northeastern Brazilian Amazon formulates an important concept in the understanding of market structures across the Amazon, namely the persistence of *aviamento* as an economic and social relationship based on violence and personalized dependence, which can even lead to slavery. This system has operated since the early colonization period and still persists, trapping a significant proportion of the local population, especially those who depend on the extraction of forest products, in an imbalanced economic system based on personal relationships, intergenerational debt, and modern slavery. Social and economic violence is at the base of this market structure.

In this context, the French geographer Pierre Gourou commented in 1948 that "the wealthiest families owe their fortune to the control of the Amazon trade; they dominate the concentration in Belém and the export of everything that the Amazon sells; they have a monopoly on introducing what the Amazon buys. These suppliers [*aviadores* in the original text] are often also colonels, that is, landowners, or more precisely, river owners". The commercialization of forest products in the first half of the twentieth century was sustained by non-competitive markets, in which buyers of local products also sold producers staples not available locally.

This finding is important because it shows that there is an economy of forest socio-biodiversity in the Amazon, but one characterized by personalized forms of domination that are obstacles, not only to competitive markets, but also to innovative initiatives aimed at adding local value to what is extracted from the forest.

This process has been extensively described in the literature, but few quantitative data are available, even in current practices. The best *aviamento* analysis was done by the Brazilian Federal Public Ministry (MPF) in the state of Amazonas, on the extraction and commercialization of piaçava and ornamental fish in the Rio Negro region. There, MPF found modern slavery and an *aviamento* market structure in which non-monetary exchange and indebtedness were widespread.

The result is that the "unfair distribution of income to extractivists and producers and their financial dependence on intermediaries and middlemen, the historical *aviadores*, have been part of local commercial relations for decades and constitute one of the most difficult paradigms to be broken" (Freitas and Schor 2020).

This market structure, as synthesized by Conexsus (2020), is an obstacle for countless cooperatives and associations to "identify the commercialization opportunities represented by the differentiated agricultural and extractive products that they produce". At the same time, companies interested in these products are unaware of their immense variety and end up missing promising opportunities for new products. Most of the time, as shown by Conexsus' work, companies interested in biodiversity products end up buying them from intermediaries within value chains that discourage the emergence of dynamic and competitive markets.

Both the work from Brondizio *et al.* (2021) and Conexsus (2020) show that non-timber forest products are extracted and commercialized by hundreds of individual producers and family networks, or groups organized in associations and small cooperatives. However, the functioning of these local organizations, in the overwhelming majority of cases, exhibits administrative and operational deficiencies (for example, to negotiate sales and export contracts, or to meet sanitary standards), and a lack of transportation, storage, and processing infrastructure. They are informal, do not possess an accounting record of their operations, and depend on incomplete and imperfect markets (Futemma *et al.* 2020; Brondizio 2008). Of the 374 communal enterprises analyzed by Conexsus (2020), only 20% go beyond planting to process their own products. In this context, it is clear that these initiatives do not have access to financing mechanisms capable of offering them the means to invest in improving their capacity.

30.4.3 Fishing and Pisciculture

The Amazon is a hotspot for aquatic biodiversity (Tedesco *et al.* 2017; Leroy *et al.* 2019), with Amazonian fish representing approximately 13% of all freshwater species described worldwide (see Chapter 3). Additionally, the Amazonian coast is part of the Amazon-Orinoco Influence Zone, considered an Ecologically or Biologically Significant Marine Area (EBSA) under CBD's criteria, including high biological productivity and biodiversity (CBD 2014).

Fisheries have a major impact on food security and local and regional economies in the rural Amazon (see Chapter 15; Tregidgo *et al*. 2020). In certain areas of the lower Solimões River and upper Amazon, it is the main source of protein for human populations, although in urban regions fish is far from the cheapest protein option.

In Brazil, fishing in the Amazon is classified into four subsectors discernable by different socioeconomic dynamics and sustainable management approaches. Subsistence fishing (for self-consumption) exploits a great diversity of species. It is a dispersed activity practiced by thousands of people; therefore, it is difficult to quantify its production.

Commercial fishing is carried out across the entire Amazon Basin and Amazonian coast and supplies local and international markets. However, reliable long-term statistics are unavailable (see Chapter 23). The composition of continental fisheries varies according to each specific region, with more than 90 species recorded on dockings, although approximately 80% of the production consists of only 6 to 12 species (or group of species; Batista *et al*. 2012; Pinaya *et al*. 2016; Lima *et al*. 2017). In general, Characiformes and Siluriformes are the most relevant orders of fish (Zacarkim *et al*. 2015; Garcez *et al.* 2017), and the main fishing resources include curimatã (*Prochilodus nigricans*), jaraquis (*Semaprochilodus insignis* and *S. taenirus*), tambaqui (*Colossoma macropomum*), dourada (*Brachyplatystoma rousseauxii*), filhote (*B. filamentosum*), mapará (*Hypophthalmus marginatus*), pacus (*Myleus* sp., *Metynnis* sp., and *Mylossoma* sp.) and surubins (*Pseudoplatystoma fasciatum* and *P. tigrinum)* (Batista *et al*. 2012; Ruffino 2014).

On the Amazon coast there are industrial and artisanal fisheries. Industrial fisheries target piramutaba (*Brachyplatystoma vaillantii*), pargo (*Lutjanus purpureus*), and pink shrimp (*Penaeus subtilis* and *P. brasiliensis*), while artisanal fishing targets many species, but mainly the Perciformes and Siluriformes, such as pescada amarela (*Cynoscion acoupa*), pescadinha gó (*Macrodon ancylodon*), gurijuba (*Sciades parkeri*), uritinga (*S. proops*) and bandeirado (*B. bagre*), in addition to the manual capture of uçá crab (*Ucides cordatus*) (Jimenez *et al*. 2020; Isaac *et al.* 2009; Almeida *et al*. 2011). Another important product for international trade is swim bladders (locally known as "grude"), a by-product highly valued in China. Brazil is one of the main suppliers of "grude" to the Chinese market (Sadovy de Mitchelson *et al*. 2019), and more than 97% of Brazilian production comes from the Amazon coast (MDIC 2021).

The main targets of sport fishing are the tucunarés (*Cichla* spp.), but other species are also caught, such as traíra (*Hoplias malabaricus*), pacus (genera *Mylossoma*, *Myleus* and *Metynnis*), piranhas (*Serrasalmus* spp.), Corvina (*Micropogonias furnieri*), pescada branca (*Plagioscion squamosissimus*) and pescada amarela (*Cynoscion acoupa*) (Ruffino 2014; Frédou *et al.* 2008).

In addition, small ornamental species are captured live for the aquarium trade. Brazil and Colombia are responsible for most exports of Amazonian ornamental fish, with the states of Pará and Amazonas (Brazil) primarily responsible (Tavares-Dias *et al.* 2009; Benzaken *et al*. 2015; Zehev *et al.* 2015). In 2014, Brazil exported USD 13.5 million in ornamental fish, with the states of Amazonas and Pará responsible for 88% (Faria *et al*. 2016; Araújo *et al*. 2017; Sousa *et al*. 2018). Targets include cardinal tetra (*Paracheirodon axelrodi*, the most exported fish), neon green (*Paracheirodon simulans* Géry), rodóstomos (*Hemigrammus bleheri* Géry & Mahnart), rosaceu (*Hyphessobrycon* spp.), butterfly-fish (*Carnegiella* spp. and *Apistogramma* spp.) and rays (*Potamotrygon* spp.). In the Xingu River (State of Pará), acari picota ouro (*Scobinancistrus aureatus*, the most valued species), acari amarelinho (*Baryancistrus xanthellus*), acari pão (*Hypancistrus* sp.), acari tigre de lista (*Peckoltia vittata*), and acari bola azul (*Spectracanthicus punctatissimus*) (Araújo et al. 2017) are exported mostly to international markets in the United States and Europe (Araújo et al. 2017).

The pirarucu, so called in Brazil and Colombia or paiche in Peru (*Arapaima gigas*), is one of the most emblematic Amazonian species. It is one of the largest freshwater fish in the world, commonly weighing 125–200 kg, and widely distributed in the Amazon Basin (Brazil, Peru, Colombia, and Bolivia). According to the Brazilian National Supply Company (CONAB 2020), there are 32 management areas in 19 municipalities in the state of Amazonas (Brazil), with fishing permits for 58,457 units/year, exhibiting a 164% increase in permits from 2011 to 2018. The gross income provided by the commercialization of pirarucu managed in these areas reached BRL 8 million a year in 2018, with a net income of approximately BRL 2,000/family. This is significant if we consider that the average HDI (Human Development Index) of municipalities in this area is 0.541 and per capita monthly incomes of the poor and extremely poor are below BRL 140 and BRL 70, respectively.

One of the main threats to the resource in this region is predatory fishing and high levels of bycatch. Fisherfolk discard tons of unwanted or untargeted fish to make room for high-value species in the boat. The low participation of fishing communities in management and governance processes is also a serious problem, which ends up stimulating predatory practices responsible for reduction of natural stocks and territorial conflicts between fisherfolk. Communal fishery agreements to define terms of common use or shared management of certain lakes are important. In the State of Amazonas, there are approximately 70 recognized fisheries agreements. The exemplary Mamirauá project has stimulated the development of similar initiatives in several regions (Queiroz and Peralta 2006; Viana *et al.* 2007; Amaral 2009).

Heavy metal contamination of water from illegal mining is also an alarming trend (see Chapters 20 and 21). A study by Fundação Owaldo Cruz (Fiocruz) in partnership with the World Wide Fund for Nature (WWF-Brasil) in the Tapajós River Basin showed mercury contamination in 100% of examined Munduruku people, mainly owing to the consumption of fish, an important protein source of Indigenous and riverside communities (WWF 2020). In an analysis of 88 fish specimens from 18 species, 100% of samples were contaminated with mercury. A similar study conducted by WWF-Brasil and ICMBio in Amapá state assessed the level of mercury contamination around the Tumucumaque National Park and the Amapá National Forest. Of the total animals sampled, 81% were contaminated with mercury (WWF and ICMBio 2017).

As with terrestrial value chains, lack of infrastructure limits the economic growth of fisheries. Lack of access to reliable energy subjects fisherfolk to the whims of local agents who own ice factories. The dearth of storage, processing, and transport capacity forces fisherfolk who live far from consumer centers to sell to brokers at extremely low prices. This is aggravated by fragile social organization, which hinders the battle for fairer trade. A shortage of technical assistance and access to credit is also a challenge (Jimenez *et al.* 2020).

Reductions in natural fish stocks have driven increases in captive fish production in the Brazilian Amazon, which is also an important sector of the region's bioeconomy in terms of income and food security. Multiple forms of fish farming have been tested, including artificial tanks, damming springs, closing segments of streams, floating cages, and even restocking lakes and ponds. A species that receives much attention is the tambaqui (*Colossoma macropomum*), with an annual production of 73,181 tons in 2019 (72% of the national production, moving BRL 535 million), followed by the pirarucu with 1,679 tons (88% of the national production, and BRL 21 million).

Despite this growth, there are important bottlenecks. High feed costs make captive farming uncompetitive because extractive fishing is cheaper and many consumers prefer fish from the natural environment. High energy costs and unreliability of energy supplies compromise the propagation of juvenile fish, which depend on oxygenation of the water. According to Christian Jesús Méndez, the problems associated with fish farming in Peru (and by extension the region) include low levels of technology throughout the entire production chain, ranging from fish feed production to the sale of fish; poor business management processes; lack of collectives and associations; and lack of funding for applied research to overcome the aforesaid limitations or even for official time-series surveys (INPA 2018). Luiz Eugênio Conceição underlines some measures that could increase the potential of Amazonian fish farming; e.g., focusing on noble species with high nutritional value and good genetic load, increasing production volume to reduce transport costs, promoting integration and partnerships among fish farmers, and improving breeding, larvae production, water management, animal welfare, processing capacity, transport, meat quality, and marketing conditions. Another intervention is boosting the development of certification processes (INPA 2018). Promising results have been obtained with modern and more efficient salting, drying, and freezing techniques, as well as in adding value by producing burgers and products that are smoked, crushed, breaded, or marinated, and surimi (Jesus *et al.* 1991). Technological treatment has also been applied in the transformation of fish skin into several products, from clothing to bags and wallets; as well as using skins and bones in the production of collagen for foods, cosmetics, and nutraceuticals.

Fish processing waste can be used to produce biogas, bio-jewelry, handicrafts, animal feed, and food for human consumption (e.g., hamburgers, sausages, nuggets), reducing the environmental impact of waste and generating even more income (Jimenez *et al.* 2020).

30.5 Bioeconomy Services

In the previous section, we analyzed three biodiversity products and showed their importance for the subsistence and income of the Amazonian population. This cannot disregard the technological deficiencies that characterize exploitation and use of these products, as well as the incomplete and imperfect character of the markets in which they are commercialized. It is important to note that biodiversity also offers a range of services to humans that are fundamental to the emergence of a new bioeconomy of standing forests and flowing rivers. These services are not always expressed in markets that value their social relevance. The first one is forest regeneration, an urgency derived from the fact that most of the areas deforested in the last fifty years are abandoned or occupied by low productivity activities, particularly livestock. The second is tourism, and the third is payments corporations, public, and private organizations may make to conserve and expand standing forests and flowing rivers.

30.5.1 Synergies between the Bioeconomy and Forest Restoration

"Forest landscape restoration" encompasses a variety of strategies to increase tree cover, from tree planting and silviculture to ecological restoration (Mansourian *et al.* 2017; Chapter 28). Forest landscape restoration not only re-establishes a forest's ecological functions but also expands the supply of timber and NTFPs, restores ecosystem services, and helps recover biodiversity (Chapter 28). These landscapes then create new opportunities for increasing and diversifying supply chains, supporting innovation, creating jobs and income, and ultimately improving local peoples' well-being. This section discusses the synergies that might arise from undertaking forest restoration at scale and the bioeconomy, providing some examples of key on-the-ground experiences and pointing out some directions to the future.

Seedling planting and agroforestry are among the most common strategies for forest restoration in the Brazilian Amazon (Aliança para Restauração da Amazônia 2020; Chapter 28). Although agroforestry is found across all Amazonian countries, it is restricted to small areas, such as home gardens, whereas planned AFS are limited to local pilot projects mainly funded by international cooperation (Porro *et al.* 2012). Natural regeneration is a restoration strategy that can be widely adopted given the wide distribution of abandoned agricultural lands (Smith *et al.* 2020; Silva-Junior *et al.* 2020). This strategy is cost-effective, considering the low costs associated and high biodiversity and carbon returns (Ferreira *et al.* 2018; Lennox *et al.* 2018; Strassburg *et al.* 2020). However, it has still received little interest from the point of view of harnessing socio-biodiversity products.

Independent of the restoration strategy involved, business opportunities are often created across the restoration supply chain, involving for example seed collection, seedling production, nurseries, plantation management, and harvesting of forest products (Brancalion *et al.* 2017). In terms of seedling planting, perhaps the most prominent example is the Xingu Seed Network (Rede de Sementes do Xingu) in Brazil. This initiative, led by the non-governmental organization (NGO) Instituto Socioambiental (ISA), deals with seed exchange and commercialization. During the last 14 years, it has traded approximately 250 tons of seed from more than 220 species native to the Cerrado and Amazon, with a revenue of approximately US $782,000. The most prominent feature of the initiative is their engagement of over 500 people, including Indigenous groups, family farmers in agrarian reform settlements, and city residents, in collecting seeds and undertaking other activities in a cooperative model. The strong involvement of local communities across the restoration supply chain (Schmidt *et al.* 2019) might inspire other initiatives and potentially increase the scale of restoration across the region. In the Xingu Seed Network, innovation lies in linking together important actors, such as landowners, Indigenous people, government, and non-governmental organizations.

Agroforestry is often seen as the most promising restoration strategy as it can reach millions of family farmers living in the Amazon, and can align conservation and socioeconomic objectives (Porro *et al.* 2012). This approach relies on decades of experimentation by government institutions, NGOs, and farmers that culturally reproduce traditional systems across generations. The adoption of agroforestry and access to markets for bioproducts associated with forest restoration can benefit from many decades of successful experience in production, cooperativism, trading, and certification in different parts of the Amazon. Among emblematic examples led by family farmers in the Brazilian Amazon are the Mixed Agricultural Cooperative of Tomé-Açu (CAMTA) in Pará (Box 30.1) and the Agroforestry Program RECA in Rondônia, both focused on fruit pulp production, and 'Café Apuí' for coffee production in Amazonas.

It is true that in the context of ecosystem restoration, improvements in many agroforestry systems are necessary to achieve environmental objectives, such as increasing local biodiversity and structural attributes in ways that make them more similar to natural ecosystems.

30.5.1.1 Fruit Trees

Despite necessary adjustments to agroforestry systems for restoration, there is already a large amount of traditional and scientific knowledge on the cultivation of native Amazonian species in agroforestry, including açaí, Brazil nut, cocoa, cupuaçu, and pupunha (*Bactris gasipae*). Currently, economic revenue comes from selling the fruits *in natura*, i.e., producing fruit pulps individually or in cooperatives.

The implementation of extractive timber and NTFP activities in agroforestry plots (i.e., areas that are distant from large patches of primary forest) circumvents many of the limitations associated with extractive activities, widely discussed in section 30.4. Restoring areas with planted agroforestry allows farmers to have better control, such as increasing the presence and density of plant species of economic interest and planting at a distance that facilitates harvesting and processing. Managed agro-ecosystems can also enable or improve working conditions, as is the case for harvesting açaí, whose palms grow taller in natural *várzea* ecosystems.

Figure 30.5 Agroforestry system with banana, cupuaçu, taperebá, açaí, inga, mogno, andiroba, and paricá. Photo: Embrapa/Ronaldo Rosa.

Although agroforestry often includes a variety of plant species, the motivation for adopting systems is often based on a few individual species (e.g., aça) which can guarantee profitability. Açaí, one of the most desirable species at present, is especially suited to the restoration of riparian zones subject to flooding and has the advantage of easy propagation and high seed availability. Demand for the species may increase, not only because of the growing economy of pulp production, but also for industrial products with higher added value (e.g., medicine and production of panels, as discussed above).

Another key native species for agroforestry is cocoa, owing to favorable market prices and high demand in the national and international market. In the Brazilian Amazon, cocoa agroforestry plantations have been mostly restricted to areas with rich soils in the Transamazon region of Pará, but recently efforts are being made to increase production in other regions of Pará. Different initiatives have been successfully promoted to produce chocolate locally. One example is a family farm on Combu Island in Belém. The family, led by Mrs. Nena, produces up to 300 kg of cocoa each month and supports tourism, the main economic activity on the island. The family supplies high-end restaurants owned by celebrated chefs from Belém and São Paulo. Chocolate production also gathered 40 family farmers in the COOPATRANS cooperative (Cooperativa Agroindustrial da Trans-Amazônica) to build an agro-industrial plant and created the brand Cacauway, which sells their products in cities across the state.

Cocoa agroforestry to restore degraded pastures has been the focus of a socioenvironmental project led by the NGO The Nature Conservancy (TNC) in one of the most pressing agricultural frontiers of the Brazilian Amazon. The Cacau Floresta ("Forest Cocoa") project in the southern Amazon encourages small farmers and ranchers to recover defor-

Box 30.1 Agroforestry Systems

The need to reconcile productive land use with forest conservation and regeneration has stimulated the emergence of AFS. EMBRAPA conducts research and advisory activities in this area, and the practice has come a long way (EMBRAPA 2020). In Tomé-Açu, in the State of Pará (Brazil), agroforestry practices began at the end of the 1960s, when agrobiodiversity served as a solution to a serious crisis caused by disease and low prices for black pepper monocultures (Homma 2016). The region implemented adapted forms of traditional cultivation systems unique to the region, self-named the Tomé-Açu Agroforestry System (SAFTA) by promoters of these systems. The region has become not only an important export hub for products with higher added value (especially to Japan and the United States), but also an example of agroforestry innovation in Brazil and abroad.

In 1987, farmers implemented an agroindustry program to process fruit pulp produced in SAFTAs. In the 1930s they had already founded a cooperative that would later become the Mixed Agricultural Cooperative of Tomé-Açu (CAMTA) (Homma 2016). Today, the cooperative consists of more than 170 members and 1,800 family farmers registered to supply raw materials. Commercialized products include black pepper, cocoa bean, herbal oils, and regional fruit pulps. Members of the cooperative estimate that 10,000 jobs (direct and indirect) have been generated. Although many exotic commercial species are grown in SAFTAs, especially black pepper, Amazonian native plants such as cocoa (*Theobroma cacao*), cupuaçu (*Theobroma grandiflorum*), açaí (*Euterpe oleracea*), taperebá (*Spondias mombin*), and Brazil nuts (*Bertholletia excelsa*) are integrated in these systems. Native wood species are also frequently cultivated, such as ipês, cedar, and paricá (Barros *et al.* 2009).

Tomé-Açu farmers cultivate in integrated production systems with a greater diversity of products, guaranteed access to markets, and greater added value resulting from agro-industrial processing. This is considered a major success for the region. What can explain these examples of more sustainable agricultural systems in regions (such as the northeast of Pará) where mainstream forms of production degrade ecosystems and promote little socioeconomic development? Answers to this question are certainly important to boost the bioeconomy and bring large-scale transformation to the Amazon.

Tomé-Açu was founded by Japanese immigrants to the Amazon in 1929, as part of a cooperation treaty between Brazil and Japan (Homma 2016). While this unique story restricts many generalizations, some lessons emerge and may be applied to other contexts. Cooperativism and collective work have always characterized the region's production systems, regardless of culture (Saes *et al.* 2014; Tafner-Junior and da Silva 2011). Immigrants took a very innovative stance in the face of crises and experimented, based on technical support, both in the production system and with products.

Above all, technical and financial support from the Japanese government in various periods of crisis played an important role. This support was important not only as direct agricultural investment, but also to build essential infrastructure, overcoming deficiencies of the State, as in the case of rural electrification (Tafner-Junior and da Silva 2011). This example shows, among other aspects, how important it is to promote cooperation and symmetry among players (Futemma *et al*. 2020), in contrast to the exploitation and cliental relations that currently dominate the Amazon.

Finally, it is worth noting that many family farmers in the region (settlers) also reproduce AFS inspired by Japanese descendants (Futemma *et al.* 2020). It is important to encourage biodiverse agroforestry and expand markets for new products so that these niches can progress towards sustainable regional development.

ested or unproductive areas by planting cocoa and other forest species of high economic value. TNC has announced partnerships with two big internat ional chocolate companies, Olam (Singapore) and Mondelez (US).

30.5.1.2 Timber

The production of timber has received less attention than NTFPs in agroforestry or any other mixed-species restoration system. Despite its significant potential to improve vast areas of degraded pasture in the region, silvopastoral systems primarily rely on exotic species such as *Eucaliptus spp*. or Teca (*Tectona grandis*). This is, in part, due to limited market access for planted timber, scarcity of knowledge of silviculture of native species, and lack of financial support for tree crops that require longer time frames (and more financial risk). However, as previously mentioned, the market for planted timber is growing rapidly, following declines in the supply of timber from native species and consumer preference for more sustainable products (Veríssimo and Pereira 2014). The cultivation of timber species in restoration areas can boost the timber market, a relevant economic sector in the region. Fostering innovation is crucial in this sector, which is still dominated by largely unspecialized activities. According to Veríssimo and Pereira (2014), wood production in the Brazilian Amazon consists of 86% sawmills, 8% processed timber, 5% laminate industries, and 1% wood boards. Agro-industrial activities for producing medium-density fiberboard (MDF) are promising, as this sector requires large volumes of wood material. Paricá, naturally occurring in Brazil, Peru, and Colombia, is the only native species with the capacity to replace exotic *Eucaliptus* and *Pinus* species. Paricá is extremely fast-growing, has been widely planted both in monocultures and AFS in the region, and yields as high as or higher than *Eucaliptus* grown in 4–7-year cycles (Melo *et al.* 2014). Mahogany (*Swietenia macrophylla*) plantations also present high growth rates and commercial value (Veríssimo and Pereira 2014). Efforts are needed to identify a diversity of fast-growing native species, as well as to improve the efficiency of timber processing and related machinery. The Paragominas region (Brazil), once infamous as the largest source of illegal timber in the Amazon, has transformed to become a good example of industrialization in more specialized markets for planted timber. With eight companies distributed across six municipalities, it has been producing MDF boards through processing Paricá timber (ABIMCI 2019). Industrial demand for these products in the region was not met by production from ~38,000 hectares planted in recent years (Santos *et al.* 2018), indicating there is plenty of room for growth.

30.5.1.3 Other Products

Beyond timber products, it is important to emphasize that restoration systems can provide diversified NTPFs, including rubber, gum, wax, fibers for dyeing, aromatics, and medicines for several sectors, including chemical, pharmaceutical, automotive, and food (MAPA 2018). Examples of oil species already traded in the market (see above) include andiroba (*Carapa guianensis*), buriti (*Mauritia flexuosa*), copaíba (*Copaifera spp*.) and babassu (*Attalea spp*.).

In conclusion, we have presented several promising examples of partnerships between local communities, private companies, and NGOs for supplying Amazonian NTFPs to industry, such as Natura Cosmetics and Beraca, that trade in oils and other bioproducts. Such programs also benefit private companies by improving their socioenvironmental image. The relationship between private companies and local communities can have local benefits, but are full of complexities and caveats (Morsello 2006). It is paramount that these partnerships guarantee the empowerment and autonomy of the IPLCs involved (Ribeiro 2009).

Funding and partnerships linked to restoration activities are emerging in the region, with Belterra and Conexsus Sustainable Connection Institute mobilizing a large network of associations, cooperatives, and small- to medium-size companies to increase access to funding and markets for sustainable bioproducts. These innovative systems should complement strong public policies, such as credit for restoration and institutional programs for purchasing products from family farmers engaged in restoration. The Food Procurement Program (PAA) and the National School Meals Program (PNAE) in Brazil are good examples of initiatives that purchase socio-environmentally friendly produce from smallholders that could be scaled up (Resque *et al.* 2019).

Beyond the marketing of products, restoration using agroforestry is important for the well-being of rural families, providing food security through the cultivation of a wide variety of high-value products, and a range of other benefits such as climate mitigation and improved water and soil quality (see Chapter 28).

30.5.2 Tourism

Tourism is one of the fastest-growing economic activities in the world. Outstanding natural beauty, cultural diversity, and historical significance are among the most relevant factors for tourism demand (Cho 2010). The Amazon's immense sociobiodiversity puts it in a privileged position. Calderón (2015) highlights the biological, cultural, and geographical diversity of Ecuador as a great strength and opportunity for the development of tourism in that country, an argument that can be easily extended to other countries in the Andean Amazon region. Sinclair and Jayawardena (2003) point to a similar conclusion for Guyana. Castro *et al.* (2015) emphasize the importance of environmental quality for tourism in protected areas in Brazil. Tourism and environmental conservation are often intrinsically related; a study by the Escolhas Institute (2019) shows that, according to Amazonas Cluster Turismo, touristic areas are much less affected by fires and devastation than areas where tourism does not occur.

Nature is considered a decisive factor for travelers' choice of destination, for both foreign and domestic tourism. A study of the Comisión de Promocion del Peru para la Exportación y el Tourism (PromPeru 2019) found that 53% of domestic tourists consider "landscapes and nature" as a decisive factor. However, the Peruvian Amazon was not on the list of most-visited destinations, indicating the Amazon's potential is still limited. Similar trends can be observed in all countries of the region.

Rodrigues *et al.* (2018) estimated there were 16.8 million visitors to 209 Brazilian National and State Parks in 2016, with an economic impact of US $1–2 billion annually. However, less than 5% of those visits were in the Amazon. A similar result was presented in a study on ecotourism in Colombia, which showed that the Colombian Amazon is a relatively marginal destination compared with tourists in other parts of the country (Sánchez and Tsao 2015).

It is critical to understand the challenges for tourism in the region. Ochoa-Zuluaga (2019) argues that tourism in the Amazon is characterized by two distinct realities occupying the same space: commercial capitalism and local communities, which, although partly integrated into the market, maintain traditional forms of subsistence and social relations that are in conflict with conventional tourism. Capucci (2016), when analyzing the growth potential for tourism in Suriname's countryside, highlighted the problems that can originate owing to contact with foreigners if expansion is not properly controlled, both for nature and for communities that were previously isolated. Taking the Colombian Amazon as a reference, Ochoa-Zuluaga (2019) contrasts the substantial expansion of tourism around Leticia, with an increase in hotels and services for tourists, with the social conditions of local communities, which remain quite precarious despite the considerable increase of business and income. The challenge is to expand tourism while also improving the well-being of Amazonian populations and without significantly changing the spatial configuration of countryside towns and settlements, especially near isolated IPLCs.

For this reason, it is paramount to develop differentiated approaches in which the growth potential of tourism is not antagonistic to the principles of socio-biodiversity, which is ultimately its main drawcard. This means that it is not enough just to conserve the region's natural characteristics; it is also necessary to respect and value its historical and cultural legacy.

In an assessment of the potential of community-based tourism in Indigenous areas in the Colombian Amazon, Quintana Arias (2018) argues that by understanding art and territory as a social construct of the tourist reality, the importance of the symbols and myths that outline the social praxis resulting from the intersection between cultural and biological diversity increase. This appreciation of ancestral knowledge is also manifested in other cultural, artistic, and religious expressions that make the Amazon special. This includes popular festivals of religious origin, such as the *Círio de Nazaré* in Belém do Pará, as well as secular events, such as the *Boi de Parintins* in the Brazilian state of Amazonas. It is also necessary to explore the cultural mosaic of the diverse peoples who moved to the Amazon, as evident in the extraordinary ethnic diversity of Guyana, where the multiplicity of native languages reflects African, Asian, and European origins, resulting in one of the most culturally diverse populations on the planet, amid an equally diverse natural environment.

To this end, it is important to avoid myths such as the "return to El Dorado" or other fantastical constructions that identify forest dwellers as "good savages". As argued by Sinclair and Jayawardena (2003, p. 402), "The product in Indigenous tourism in Guyana and Surinam is often an equation that is as much myth as reality".

Following World Tourism Organization principles and based on experiences in the Ecuadorian Amazon, Arroyo and De Marchi (2017) identified key criteria to be respected in the development of tourism, especially schemes that are community-based: (i) self-determination in the implementation and execution of the activity; (ii) plurality, reflecting all the players involved in touristic work; (iii) participation, which allows visualizing horizontal relationships in the practice of tourism activity; (iv) scope, in which articulation with other economic spheres is reflected; (v) transparency, which constitutes the honest and ethical management of the resources available for the touristic activity; and (vi) progressivity and planning.

Another important aspect is to encourage demand for tourists interested in a different type of tourism. Sinclair and Jayawardena (2010) highlight the potential to develop routes integrating the Amazon and Andes, possibly connecting Inca trails to the Guyanese Massif, and leveraging river routes throughout the entire region. Benevides *et al.* (2018), in a study of Roraima (Brazil), underline the importance of social innovation and creativity to increase the well-being of visitors. Insecurity, lack of transport, and lack of infrastructure are some of the barriers to be overcome to strengthen the tourism sector.

Arroyo and De Marchi (2017) draw attention to the principle that sustainable tourism is a means for development, but not an end in itself, and that tourism can be compared with an "iceberg", consisting of a small visible part (experienced by tourists) and a large non-visible component, composed of a mosaic of local initiatives, strategies, and investment coordinated by the public sector. Therefore, it is essential that this invisible part also benefit communities through better living conditions and generate positive citizenship effects. This requires coordination between market operators, development institutions, and local populations, respecting their heterogeneity and recognizing that, in community-based tourism, communities are the managers, producers, and administrators of their own tourism products and in control of the business. Tourism activity can significantly strengthen community organization, bonds, and identities, but also generates significant processes of appropriation, management, and organization of natural and cultural heritage. It is also worth mentioning tourism connected to Saint Daime Ayahuasca, and its impacts on cities such as Pauini (State of Amazonas, Brazil) (AMVCM 2021).

Recognition of this immense heterogeneity requires in-depth knowledge of resources, accessibility networks, and use of touristic resources so that an articulated tourism policy that respects the knowledge systems, cultures, religions, and local traditions that guarantee the conservation of sociobiodiversity can be developed for the Amazon.

30.5.3 Payment for Environmental Services

The Amazon is home to numerous terrestrial and aquatic ecosystems that provide invaluable environmental services (see Part I) to humanity. The most evident and debated are those provided by native vegetation, which represents a remarkable share of global biodiversity (see Chapters 2–4). The wealth is so great that it is possible to find more species of ant on a single Amazonian tree than can be found in the whole of the United Kingdom (Wilson 1987). In addition to being a repository of immense biological diversity, the Amazon stores more than 150 billion tons of carbon in its soils and vegetation (see Chapter 6). If this carbon is released into the atmosphere via deforestation and degradation, it would significantly aggravate global climate change. However, the importance of maintaining ecosystem services vital to human well-being has been little recognized, valorized, and compensated. In this sense, PES can potentially contribute to the large-scale protection of Amazonian ecosystems and their environmental services.

Compensation for ecosystem services are economic incentives to support the conservation or sustainable use of natural resources, aiming to induce behavioral change through the valuation of one (or more) services (e.g., climate regulation, water conservation) (Wunder 2015; Pagiola *et al.* 2016).

There are countless PES experiments in the Amazon involving the protection of water resources (Moreno-Sanchez *et al.* 2012; Montoya-Zumaeta *et al.* 2019; Young *et al.* 2019) and biodiversity (Machado et al. 2020). Castro *et al.* (2018) estimate that PES initiatives aimed at forest conservation in communities in the States of Acre (Certificate of Family Production Unities) and Amazonas (Forest Grant) benefited over 44,000 individuals between 2009 and 2015, and allocated over BRL 40 million. Other initiatives involve compensation for GHG emission reduction owing to avoided deforestation, known as "reduced emissions from deforestation and forest degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks" (REDD+) under the United Nations Framework Convention on Climate Change (UNFCCC). In general, entities (jurisdictional or not) that can demonstrably reduce GHG emissions from deforestation are eligible to receive compensation through REDD+. Actions aimed at the conservation, management, and expansion of forests are also contemplated (the "+"). This mechanism has been debated for over a decade within the UNFCCC and several independent groups, but several bottlenecks still need to be overcome to advance the program (Angelsen *et al.* 2012; Duchelle *et al*. 2018; West *et al*. 2020). In the tropics, pilot REDD+ initiatives have been implemented, including in the Brazilian and Peruvian Amazon (e.g., Sunderlin *et al.* 2014; West *et al.* 2020). Although REDD+ initiatives demonstrate promising results (Simonet *et al.* 2019; Sunderlin *et al.* 2014), as well as a consolidation and profusion of REDD+ initiatives (Sunderlin *et al.* 2014), they still face several challenges. One is leakage, whereby the reduction deforestation and emissions in one area pushes deforesters into other areas. Another is double counting, i.e., when multiple entities claim responsibility and benefits for the same emission reductions. Finally, unequal distribution of benefits is another persistent issue (Gomes *et al.* 2010; Moutinho *et al.* 2014; Streck 2020). To address these, REDD+ is advancing jurisdictional modalities and involving subnational government entities (Nepstad *et al*. 2012). The Amazon, especially within Brazil, historically prospered from jurisdictional REDD+. The Brazilian State of Acre was a pioneer in this process, structuring governance mechanisms (Duchelle *et al.*

2014; Guerra and Moutinho 2020) propelled by the REDD+ Program for Early Movers (KFW 2021) of the German government. The same jurisdictional REDD+ construction process took place in nine states of the Brazilian Amazon, especially Mato Grosso, Roraima, and Maranhão (Guerra and Moutinho 2020). Besides Brazil, the impetus for proposing jurisdictional REDD+ among Amazonian countries, mainly Colombia and Peru, can be summarized by the Governors' Climate and Forests Task Force (GCF 2021), which involves governors of states and provinces, not only from the Amazon, but from several states (38 in total) that hold tropical forests throughout the world.

In summary, despite numerous bureaucratic obstacles, jurisdictional REDD+ programs are rapidly advancing across Amazonian countries, particularly Brazil and Peru. Among the obstacles faced are the lack of consolidated regulations for national REDD+ strategies, both technical and political (West *et al.* 2020; Wunder *et al.* 2020), and the growth of social movements against REDD+ (e.g., Grupo Carta de Belém 2009). Independent initiatives to qualify, monitor, and inform subnational REDD+ activities are multiplying, including the recent Architecture for REDD+ Transactions (ART), an initiative that aims to improve security for potential private investors in REDD+ actions.

Despite advances in PES initiatives, there are numerous bottlenecks to be overcome so that this bioeconomy approach can effectively grow and improve. On the demand side, it is necessary to guarantee that forest conservation projects generate carbon credits that are eligible to participate in the European Union Emissions Trading System (ETS) and others in which charging for emissions surpluses is mandatory. On the supply side, it is necessary to advance the means for achieving socio-environmental safeguards (Pascual *et al.* 2014; Gardner *et al.* 2012), create procedures for the equal distribution of benefits (Moutinho *et al.* 2017), and guarantee that the positive effects of these initiatives are as comprehensive, effective, and lasting (Ezzine-de-Blas *et al.* 2016) as possible.

The full implementation of PES or its REDD+ variant will depend on progress in Amazonian countries' public policy. The most recent PES legislative initiative was Law 14.119 (1/13/2021), enacted by the Brazilian Congress, which created the National Policy for Payments for Environmental Services (PNPSA; Brazil 2021), paving the way for third sector institutions, companies, and individuals to receive compensation for environmental conservation activities. Numerous articles of this Law have been vetoed by the Brazilian federal government, compromising its effectiveness, transparency, and governance (Coalizão Brasil 2021). Later, these vetoes were overturned by the Brazilian Congress, enabling quicker progress in implementation of the policy. Furthermore, numerous PES initiatives are being implemented at the state level in Brazil and other countries, especially jurisdictional REDD+ (e.g., Simonet *et al.* 2019; Stickler *et al.* 2018; Palmer *et al.* 2017).

In the current large-scale deforestation scenario in the Amazon (Murad and Pearse 2018; Brito *et al.* 2019; Azevedo-Ramos and Moutinho 2020), PES and REDD+ mechanisms represent important allies in mitigating drastic changes in climatic patterns and promoting sustainable development and should not be disregarded.

30.6 An Emerging Transition

Strengthening the bioeconomy, following the ethical principles highlighted in this chapter, is an essential requirement for achieving the Sustainable Development Goals (SDGs) worldwide. However, the contributions from tropical forests, and particularly the Amazon, to products and services that improve not only to the welfare of local people but all of humankind is still negligible. So far, this chapter has explained the main reasons for the chasm between the Amazon and the scientific and technological frontier of the bioeconomy. In this section, we summarize the challenges and opportunities encountered in the transition from an economy based on exploitation to a new bioeconomy of healthy, standing forests and flowing rivers.

Social transitions (such as from an economy of destruction to a nature-based knowledge economy) are processes that depend on long-term factors, suffer unexpected shocks, and/or are influenced by individuals and organizations acting as political, institutional, or moral entrepreneurs. These individuals and organizations play a decisive role in the emergence of transformative social networks (Burt 2000), especially in times of turbulence. This is particularly true today, when deforestation, violence, and the invasion of protected areas might paradoxically catalyze the emergence of innovative solutions (Folke *et al.* 2020). The protagonists of these innovations establish bridges, alter agendas, and bring narratives aimed at the transformation that they aspire to achieve (Fligstein 2001a). The transition towards a nature-based knowledge economy is neither exclusively nor fundamentally technological, although science and technology have a crucial role. It also involves infrastructure, new markets, changing social preferences, dialogue between science and traditional knowledge, and other enabling conditions. It also involves cultural change in the social vision regarding forest socio-biodiversity and in educational processes themselves. As shown by Herrfahddt-Pähle *et al.* (2020), these cultural changes tend to value and expand proposals and alternatives that, until then, have remained confined to specialized niches and start to appear not only as necessary but as viable.

The transition is already underway. It was paradoxically accelerated by recent increases in deforestation, fire, invasions of Indigenous territories and protected areas, and the dire impacts of COVID-19. These events undermine the social legitimacy of current resource-use models.

When the landscape is profoundly transformed by a shock (e.g., those above), actors who developed models that until recently were in the niche stage gain prominence; new knowledge reaches a wider audience, gains legitimacy, and starts to occupy a decisive political–cultural space (Fligstein 2001b) in the organization of markets, opening a window of opportunity for unconventional innovations.

The emergence of a new, healthy, standing forests and flowing rivers bioeconomy cannot be limited to the products analyzed above, nor to the immense diversity of products that the Amazon produces. It also requires science and technology and a deep transformation of commodity production systems. The agricultural, livestock, and mining activities that currently account for most of the production value and exports in the region are systematically supported by socio-environmentally destructive practices (see Chapters 14–20). Concurrently, there is growing international and internal pressure on Amazonian countries to halt destruction. A truly regenerative economy must therefore emerge. In this sense, the aforementioned "Accord on the Amazon" includes the commodities sector as a bioeconomy component.

Imagining a healthy bioeconomy alongside predominantly destructive practices is a truly dystopian scenario. International and Latin American markets increasingly demand that soy, meat, cotton, and corn from the Amazon be produced with regenerative techniques that contribute to the strengthening of forest resilience and regional biodiversity. Scientific research in each country takes this beyond the theoretical, with many pilot programs. These production alternatives pave the way for a drastic and necessary reduction of damage from the agricultural sector. The experience of Paragominas and the Green Municipalities Program (da Costa and Fleury 2015), aimed at reducing deforestation and improving the livestock production, contributes to profitable and more environmentally sustainable agriculture. The agriculture and livestock commodities sector should have every interest in ensuring that all its production is certified not only as deforestation-free, but also as a vector for the enrichment and sustainable use of the forests within their properties.

In short, the emergence of a new bioeconomy of healthy, standing forests and flowing rivers is an urgent transition that can be compared with the global challenge of "deep decarbonization" as studied by Geels *et al.* (2017). It requires the transformation of consolidated productive systems (albeit of low productivity), whose inertia is broken both by the loss of social legitimacy and by the emer-gence of innovative activities that, given changing national, regional, and international contexts, gain new opportunities to assert themselves. It is clear that, similar to the urgency of deep decarbonize-tion, the mobilization of diverse actors and the application of public policies aimed at accelerating the transition are paramount.

30.6.1 The diversity of Actors

The acceleration of deforestation, forest fires, and illegal and criminal activities in the Amazon, especially from the beginning of 2019 (principally, but not only, in Brazil; Butler 2019) resulted in an intense mobilization, not only of activist organizations, but, in an unprecedented way, of businesses from the Amazon and other countries that until very recently did not actively participate in public discussions about the destiny of the Amazon. The return of the United States to the Paris Agreement, and the adoption of the Green New Deal with ambitious commitments to decarbonize the North American economy are cause for optimism. This is further supported by the adoption of the European Green Deal, and important commitments from major GHG-emitting countries, including China, India, and Japan. These developments have altered the international framework, making the immediate halt of the Amazonian destruction a global priority.

The social landscape within the Amazon itself has also changed significantly. Many prominent activist organizations are focused on strengthening entrepreneurship for the sustainable use of the forest. This is expressed not only in the search for business partners and the valuation of niche products produced within protected areas, but also in an effort to expand the products on offer and improve market conditions of socio-biodiversity products. Folke *et al.* (2020) show how large transnational companies are in the process of incorporating sustainability into their practices. NGOs that work on entrepreneurship (often in alliance with national research organizations, such as EMPRAPA are decisive actors for niche solutions to be incorporated into the practices of economic actors.

In addition to contributions by various NGOs and large corporations (financial and non-financial), it is important to highlight the mobilization of the scientific community and government stakeholders. In the Amazon, what Folke *et al.* (2020, p. 44) formulated as a premise for collaboration between human societies and the biosphere is taking place, namely that “Broad coalitions among citizens, businesses, nonprofits, and government agencies have the power to transform how we view and act on biosphere stewardship and build Earth resilience.”

The most emblematic examples come mainly from Brazil, but they are present in the Amazon as a whole. On June 2020, an open letter to the Brazilian government was published by global investment funds that collectively manage over US $4 trillion in assets, warning that the destruction of biodiversity represents a threat to their assets. Attacks to Indigenous peoples are also cited in the document (Pinto Cagliari 2020).

On July 14, 2020, 17 former finance ministers and presidents of the Brazilian Central Bank released a letter, entitled “For a low carbon economy”, in which they emphasized the risks derived from climate change and called for zero deforestation in the Amazon and the Cerrado, criticizing the invasion of conservation units and Indigenous territories (Chiaretti 2020a). A week later, in an unprecedented pre-competitive agreement, the three largest private banks in Brazil (Bradesco, Itaú, and Santander) launched an integrated plan for the sustainable development of the Amazon, in which the bioeconomy plays a strategic role, and called for halting invasions of public areas and Indigenous territories (Abramovay 2020b). The initiative’s originality lies not only in the pre-competitive agreement among the three banks, but also in its advisory board, composed of some of the most important scientists and socio-environmental activists in Brazil.

At the same time, food processing companies Marfrig and JBS released a report showing that, although they have control over the origin of the cattle they slaughter, it does not extend to the entire production chain, favoring destructive practices (Notícias Agrícolas 2020). At the same time, they announced goals to eliminate deforestation from their entire value chains.

There is no guarantee that these announcements will, in fact, contribute to zero deforestation and the emergence of a nature-based knowledge economy in the Amazon, as the success of these initiatives largely depends on public policy measures that fall outside the scope of these sectors, especially with regard to land policies and the repression of illegality and crime. The role of sub-national governments and local legislative bodies in this regard is extremely important. At the same time, it is important that investments made by these companies to strengthen biodiversity go through competitive processes and undergo rigorous, critical evaluations by specialists.

In 2014, in preparation for the Paris Conference, the Brazilian Coalition on Climate, Forests and Agriculture was established. It developed proposals that decisively influenced Brazilian positions at COP 2015. Comprising companies, activist organizations, and individuals linked to socio-environmental issues, the Coalition was important for the emergence of the previously mentioned "Accord on the Amazon" in 2020 (Chiaretti 2020b). The Accord (which has no defined legal character and is described as an informal, diversified network) aims to address topics ranging from public security and violence, to investment profiles for the sustainable development of the Amazon. The Accord organizes public discussions and requests documents from specialized consultants for each of these themes, enriching the discussions and seeking to expose the multiple points of view of the diverse players participating in this network.

A diversity of players was also essential for the establishment of a pact among state governments in the Brazilian Amazon (the Consortium of Governors of the Legal Amazon). The pact aimed not only to counter destructive practices, but also to create development plans for a new bioeconomy of standing forests and flowing rivers. Several of the authors of these plans actively participate in the Accord. The Accord also proposes to gather, process, and pave the way for the analysis of economic, political, cultural, and socio-environmental information on the Amazon through the Amazônia Legal em Dados ("Legal Amazon in Data") platform (Arapyau 2021), a request from the Consortium of Governors of the Legal Amazon.

Collaboration between scientists, IPLCs, socio-environmental activists, financial and non-financial companies, and state governments is recent and largely emerged as a reaction to the disruption of socio-environmental policies by the Brazilian government in relation to the Amazon. Many of the companies that have become protagonists of these initiatives have, until very recently, engaged in economic practices that have led to deforestation and disrespect for IPLCs' rights.

The transition to a healthy, standing forests and flowing rivers bioeconomy involves a broad and growing circle of forces that assume public commitments (backed by promising governance) to constructive practices. Among the Amazonian countries, this convergence of heterogeneous players is gaining the greatest relevance in Brazil. This is one of the most promising signs of the Amazon's transition towards sustainable development.

30.7 Navigating the New Bioeconomy: Challenges and Recommendations

The potential uses of the vast Amazon territory, the organizations that operate in it, and the institutions that govern the region's economy are so varied that specific approaches are required to propose pathways for the transition to a new bioeconomy. For example, strengthening niche markets demands different interventions and logic than using forest socio-biodiversity products for animal feed. Supporting Amazonian cities as leaders on gastronomy based on forest socio-biodiversity products requires investment in cooking schools dedicated to forest products, while promoting the pharmaceutical and cosmetic industries will require investments in laboratories and education programs.

Despite this diversity, it is possible to list general objectives that will favor a strong and dynamic bioeconomy in the Amazon, based on the ethical-normative recognition of the value of healthy, standing forests and flowing rivers, as well as respect for the material and spiritual culture of Amazonian peoples.

Previous chapters showed that the most important objective is an immediate halt to destructive practices incompatible with the intelligent, fair, and promising use of forest socio-biodiversity. Restoring the security of protected areas, Indigenous territories, and public lands against invaders is paramount. There is an urgent need to leverage intelligence and foster collaboration between different countries' homeland security forces, since criminal activities operate across borders (Abdenur 2019). In this sense, tracing the origin of illegal gold, widely exploited in the Amazon, is critical (Instituto Escolhas 2020).

With regard to the ambition for the establishment of a strong, competitive, and fair forest socio-biodiversity economy, a few fundamental objectives are described (without being exhaustive).

30.7.1 Cities, Infrastructure, and Internal Markets

A new bioeconomy of healthy, standing forests and flowing rivers cannot emerge as an enclave of scientific and technological advancement in a region so profoundly marked by poverty, inequality, violence, and lack of access to the conditions of basic citizenship, such as quality education and healthcare, basic sanitation, and participation in dynamic labor and product markets.

As discussed in previous chapters, the overwhelming majority of poverty and misery in the Amazon is concentrated in cities. In Brazil, the worst living conditions, according to the Social Progress Index (IPS 2021), are found in Amazonian cities. The current economy depends on cities, where products are sold and where most income is spent. Even families with strong ties to agriculture and forestry often maintain urban households for greater access to basic health and education services. Farmers' organizations are often based in cities. The use of forest socio-biodiversity products in the gastronomy of Amazonian cities has the potential to generate urban employment and income (Atala 2012).

Improving urban infrastructure, in cities large and small, is critical to fostering a dynamic bioeconomy. What geographer Bertha Becker called the "Consolidated Settlement Arc", referring to human occupations at the edge of the forest, has a decisive influence on the very development of the socio-biodiversity economy.

According to RAISG (2020), more than 60% of the Amazon's population is urban. It is important to highlight uncertainties in this statistic, not only due to the scarcity of demographic censuses in different countries in the region, but also to the varying definitions of the urban population in each of them. In Brazil, the definitions of municipal administrations may not reflect social realities; however, they guide classifications by the Brazilian Institute of Geography and Statistics (IBGE), which considers 72% of the Amazonian population to be urban. Veiga (2003) proposed a typology of three categories, used by Favareto *et al.* (2014) in the Amazonian context. According to this typology, one-third of the population of the Brazilian Amazon lives in unmistakably urban municipalities, 26% are in "intermediate" municipalities, and no less than 40% are in typically rural locations, even when they live in the center of these municipalities. These 40% live in municipalities with less than

50,000 inhabitants and a demographic density of fewer than 80 inhabitants per km^2. Inhabitants of these small municipalities' centers often have strong ties to agricultural and forestry activities and seek a second urban residence to access health or education facilities. This chapter will not detail this tripartition, but it is important to recognize it and its implications for infrastructure and the relationship with the bioeconomy, as it suggests a greater influence of the socio-biodiversity economy than would be expected in a highly urbanized region.

Current infrastructure in the pan-Amazon (Bebbington *et al.* 2020) guarantees the flow of mineral and agricultural commodities, and is frequently a vector of deforestation and invasion of protected areas. Alternatively, several low-cost investments can stimulate promising markets for socio-biodiversity products and reduce dependence on intermediaries that block economic dynamism. These include facilitating the mobility of rural populations and their access to urban services through information systems, accurate river transportation schedules, high-quality internet, and offering technical and university courses in small municipalities. It is also essential that cities contribute to strengthening the markets in which family farmers operate through cooperatives focused on the industrialization of what they already produce. Improving the industrial use of cassava, for example, is something that simultaneously strengthens the economy of the inhabitants of the interior and generates multiplier effects in cities. Two fundamental conditions are needed for this to happen; reducing information asymmetry and strengthening state support for rural economic activities.

30.7.2 Reduce Information Asymmetry

Information on markets is one of the most important premises for forest products to be commercialized based on modern, competitive structures that allow increased income and expansion of opportunities for producers. Government price guarantee policies are important but insufficient. It is critical that the production chains of socio-biodiversity products are mapped, fostering transparency to all participants and offering accessible information to producers. The grain stock exchange in Ethiopia, as described by Gabre-Madhin (2012), is an excellent example of an open and efficient system to share price information. Despite the particularities of Amazonian products, the Ethiopian case shows that producers themselves (either farmers or extractivists) can actively participate in information systems, no longer subject to intermediaries. Trade thus loses its personal nature and gains market transaction status.

As shown in previous sections, today buyers concentrate price information. In general, buyers control the price of what they sell to forest dwellers through *aviamento* and, frequently, through the debts linked to it. Information from institutionalized sources, such as a commodity stock exchange, is a fundamental component for the emergence of dynamic and competitive markets, according to a proposal elaborated by Freitas and Schor (2020). An initiative by the NGO Imazon, which for more than a decade has been collecting and disseminating the prices of NTFPs in the states of Pará and Amapá, stands out (Guimarães *et al.* 2019).

30.7.3 Seals of Quality, Scale, and Entrepreneurship

The Origens Brazil Seal operates in conservation units and Indigenous territories and has achieved significant results in incorporating products (rubber, Brazil nuts, peppers, herbal oils, and others) from these territories into the value chains of medium to large companies. Despite their importance, income generated by these products is necessarily limited due to the level of care required by a sustainable but fundamentally extractive economy, which is supported by the activities of populations living in sparsely populated areas and based on techniques that seek to avoid alteration of the environments in which they are located. Companies (e.g., Natura), and NGOs (e.g., ISA, IMAFLORA, ICV) pave the way for improvements, not only in production techniques, but also in the transparency of economic processes for the communities who are the real protagonists of these activities. The introduction of accounting to these communities, and efforts to link them to diversified markets, expand their capacities and autonomy.

These products are sold on a relatively small scale and in niche markets, representing a small fraction of the productive potential of the forest. Therefore, there are many initiatives that seek to scale such products and services. Most of these initiatives are not limited to the forest itself, seeking to encourage sustainable practices by family farmers, settlers, and large-scale farmers. Conexsus, for example, does important work organizing, legalizing, and introducing accounting techniques to associations and cooperatives. It aims to reduce the immense transaction costs embedded in relationships between companies and communities that supply socio-biodiversity products. These transaction costs drive companies to use intermediaries, which prevents associations and cooperatives from further benefiting from dynamic and competitive markets. Conexsus leads the movement "Business for the Earth", which aims to add "market intelligence to community enterprises."

Belterra is an organization that is developing land-use models that combine forests, agriculture, and sometimes livestock (see Box 30.1). Within and outside the Amazon, these models have been successfully implemented, demonstrating that productive scale can be compatible with maintaining biodiversity and a varied set of ecosystem services.

Low-cost digital devices and software also allow for product and/or ingredient traceability, which can be a competitive asset of Amazonian products. Wickbold brand bread, which reaches thousands of consumers, uses Brazil nuts and is equipped with a QR code that reveals the origin of the product, who produced it, and the socio-environmental situation of the territory where it was produced. These devices could also demonstrate how products contribute to the regeneration of degraded environments or other benefits. Natura has extensive experience in this area.

Even products that currently contribute heavily to forest loss, such as beef and soy, can be transformed. The fundamental premise of tracing (as planned by Marfrig and JBS) is that consumers can easily access information about a product's (and its components') value chains. This can become an important competitive asset for Brazilian livestock, for example by showing that pastures are sustainably managed and methane emissions offset. The work of PECSA (a spin-off of ICV, an important NGO operating in the state of Mato Grosso, Brazil) is a successful example in this direction. If large importers of animal feed seek to replace these products with sustainable local alternatives, increased production in the Amazon can also conserve biodiversity in the environments in which feed is grown.

Production scale has historically been achieved through the simplification and homogenization of natural environments. One of the most critical challenges a new bioeconomy faces is precisely that of integrating gains of scale while simultaneously strengthening socio-biodiversity. In this sense, a Royal Swedish Academy document advocates for "strengthening resilience through investing in portfolios of ecosystem services for human well-being in diversity-rich social-ecological systems" (Folke *et al.* 2020).

These organizations currently depend on philanthropic contributions, while expressing ambitions to work with private capital and business organizations, and promote entrepreneurship itself. In this sense, one of the most important conclusions of this chapter is that activist organizations (in all their diversity) play a decisive role in increasing private participation in entrepreneurship aimed at a new, healthy, standing forests and flowing rivers bioeconomy. These organizations have the capacity to influence the world, language, objectives, and methods of private investors and introduce them to the realities of the Amazon, which is very different

Box 30.2 The case of Natura Cosmetics

Operating since 1999 in the Amazon region, today Natura Cosmetics is the 4th largest beauty company in the world. Their business model is based on the use of socio-biodiversity products and services, pioneering the combination of production at scale with the promotion of sustainable development.

Over many years, Natura established relationships with agro-extractivist communities, generating income and encouraging local training, field research (such as forest management and sustainable agricultural production), and technological innovation. The challenge of combining technological feasibility at scale, quality, and a vision of sustainable development led the company to stipulate a series of processes and, with the Natura Program Amazonia, to locally establish an "Ecoparque", an Industrial Park in Benevides (Pará, Brazil) in 2011.

Natura invested in the research and development of ingredients and trained small producers in forest production and management techniques. They also supported institutional strengthening of communities and cooperatives, and established a policy for the sustainable use of products and services, based on the principles of the Convention on Biological Diversity (CBD) and a Brazilian provisional measure established in 2001 regarding the use of biodiversity. Some of the raw materials used by Natura are pre-processed in the communities, increasing added value.

The industrial park was built for local processing of raw materials and final products, with the objective of attracting other companies interested in a symbiotic industrial system. It also hosts the Natura Innovation Center in the Amazon and maintains partnerships on socio-biodiversity supply. So far, the German fragrance company Symrise has operations in the Ecoparque, and other suppliers, such as Beraca, have settled in the region.

To improve logistics and management, the company has been promoting local development through a strategy called sustainable territories. These territories are regions where there is a strong commercial relationship with socio-biodiversity value chains, and where intersectoral collectives are supported, bringing together communities, governments, NGOs, investors (e.g., GIZ, USAID, and Fundação Banco do Brasil), companies, and universities, for an expanded vision of standing forest economy hubs.

In total, the company has developed 38 bio-ingredients, produced by approximately 5,100 families, 33 agroextractive communities, 14 socio-biodiversity hubs (mainly in the Brazilian states of Pará, Amazonas, and Rondônia), and 11 community-based agroindustries.

Over the past 8 years, Natura reached a biodiversity business volume of approximately BRL 1.8 billion, which includes inputs, benefit sharing, and direct investments, while contributing to the conservation of 1.8 million hectares. They have offered professional courses to more than 3,000 people. In 2007, it supported the formation of the Union for Ethical Biotrade (UEBT) and the application of CBD practices and principles in input chains in different sectors of the economy.

Recently, UEBT practices were converted into a monitoring system (2014) and certification process (2018), both applied by Natura and other companies. UEBT certification ensures ethical biocommerce for the payment of fair prices, biodiversity conservation, and social development of Amazonian supply chains or any other supply chain of certified biodiversity (Natura 2019, 2020).

from those they are accustomed to. For instance, an early version of a document by three Brazilian banks explicitly mentioned promoting monocultures; after dialogue with activists, they came to understand that scaling up production in a tropical forest should not follow this model (Jankavski 2020).

Natura has been able to generate production on an industrial scale, while also strengthening forest socio-biodiversity, as shown in Box 30.2.

30.7.4 Government Support for Strengthening Markets

A commodity stock exchange will be further strengthened if governments adopt policies to guarantee minimum prices for forest socio-biodiversity products. Such a policy will reduce informality by generating production and market data and statistics, stimulating evidence-based public policies. Furthermore, these policies encourage accurate calculation of production costs and highlight the competitive opportunities of these products. These programs already exist in Brazil, but their budgets are very low, and information does not reach the producers who need it most, exacerbated by lack of technical assistance and low levels of organization.

The Brazilian Government guarantees minimum prices for 17 extractivist products, of which nine exist in the Amazon region: açaí, andiroba, babassu, rubber, buriti, cocoa, Brazil nuts, murumuru, mangaba, baru, carnaúba, juçara, macaúba, pequi, piassava, pinhão, and umbu. In addition to minimum prices, other policies can play an important role in strengthening forest socio-biodiversity. In Brazil, the National School Meals Program strengthened family farming by requiring a that such farms supply a proportion of school meals. In the Brazilian Amazon, this has been an important opposing factor to the tendency for school lunches to be composed of ultra-processed, low nutrition foods. Other institutions, such as military barracks, public hospitals, and prisons can enact similar programs. Institutional markets are a way to offer security to producers, consolidating trade routes.

30.7.5 Science, Technology, and Innovation

Improving living conditions in Amazonian cities and strengthening markets for socio-biodiversity products is fundamental but insufficient to overcome the challenges for developing a strong economy of forest socio-biodiversity. For humanity to fully realize the potential of the most biodiverse forest in the world, it is essential to reduce the gap between the Amazon and the global scientific and technological innovation frontier. This ambition presupposes the expansion of public and private investments in science and technology in the region. The budgets of the most important and renowned research institutes in the Amazon are far from sufficient given the territorial, demographic, and ecological importance of the region, and the potential that it represents for the development of the countries in which it is located and for humanity as a whole. Tthe National Institute for Amazonian Research and the Emílio Goeldi Museum, two of the region's most prestigious institutions, systematically suffer budget cuts, and funds are often contingent (Silveira 2019). As a result, botanical, ethnobotanical, and parabotanical research lags behind, or is undertaken by better resourced institutions abroad. Strengthening Amazonian organizations is paramount; this could include courses on socio-biodiversity at different levels, from field studies for secondary students to postgraduate studies. In addition, the emergence of a strong bioeconomy presupposes the creation of new research centers that are committed to achieving relevant results vis-à-vis the use of these resources. There are indications that conventional mechanisms for evaluating scientific research (e.g., publications in high impact journals) are insufficient to direct researchers' efforts towards the strategic objective of strengthening the emergence of a new bioeconomy. Incentives for innovation, including in processes, techniques, brands, and patents, are needed.

In addition to government resources, international cooperation plays a decisive role, not only by financing research, but also through exchange programs on biodiversity knowledge and its utilization potential. Leveraging the confluence of academic and traditional knowledge and global experiences in bioeconomy innovation can attract significant venture capital investments.

It is paramount that investments in science and technology in the Amazon also strengthen an educational system that improves understanding and utilization of its socio-biodiversity. This involves clear protocols for ensuring that economic activities and land management practices will result in the strengthening (and not in the destruction) of the natural and social tissues responsible for maintaining the forest socio-biodiversity. It also requires new curricula for students and researchers. Today, courses focus on a small number of crops, mainly exotic, planted both for agriculture and logging. The recent creation of the Forest Social Business School in the state of Amazonas (Brazil), associated with the State University of Amazonas and the Institute of Advanced Studies of the University of São Paulo, is an important step in reconciling new education modalities and approaches on biodiversity with the strengthening of entrepreneurship (UEA 2020). This type of exchange is a very promising strategy.

It is critical to highlight the role of botanical gardens, herbariums, archeology museums, and living museums such as the Kuahi of the Oiapoque Indigenous peoples, among others. The Amazon is already home to a number of academic and research institutions, located both in as well as far from state capitals (Brazil 2020b), who invest in science, technology, and innovation. This community of scientists needs increased investment for expansion and strengthening. Some efforts have been made, such as the creation of the Amazon Biotechnology Center in Manaus, BIOTEC Amazônia, and Instituto Tecnológico Vale in Belém. In addition, organizations focused on workers' professional capacitation (e.g., the Brazilian National Service of Support to Industry) have resources, structures, and laboratories that can be employed to improve the performance of industrial transformation of biodiversity products. Sanitary challenges that hinder nut exportation, for example, could be overcome.

In 2013, the Science, Technology and Innovation Plan for the Amazon recommended the integration of initiatives from multiple governmental and non-governmental bodies focused on socio-biodiversity knowledge and technological applications that could be best adjusted to its sustainable use (CCGE 2013). Initiatives such as the Leticia Pact, signed by Brazil, Colombia, Peru, Bolivia, Ecuador, Guyana, and Suriname with the goal of protecting the Amazon (Heads of State and Heads of Delegation of the Plurinational State 2019), show that integration can and must go far beyond national borders, stimulating the exchange of information and experiences between researchers, technicians, and entrepreneurs. This is a critical component of biodiplomacy, as highlighted in a letter published by researchers from several countries asking Leticia Pact signatories to strengthen transnational cooperation for the protection and development of the Amazon (Prist *el al.* 2019). The importance of biodiplomacy is expressed even in international forums that do not mention it explicitly but advocate for the strengthening of socio-biodiversity as the most important pathway for sustainable development of the Amazon, such as the Synod of Bishops held at the Vatican in October 2019 (Vatican 2019).

30.7.6 Biodiversity Molecules and Shared Benefits

The Amazon is considered a medicinal treasure and the "largest drug dispensary in the world" by many (Skirycz *et al.* 2016); however, the pharmaceutical use of these materials falls far short of its potential. Over the past 40 years, several techniques have emerged (i.e., robotics, bioinformatics, high-throughput screening, combinatorial chemistry, molecular biotechnology, CRISPr), reducing the pharmaceutical industry's interest in natural components (McChesney *et al.* 2007). However, this substitution strategy in the search for molecules has not been successful (Skiryks *et al.* 2016), and interest in natural products has returned. New drugs derived from natural products made up 60% of all drugs approved by the US Food and Drug Administration agency (FDA) between 1981 and 2010. Research also shows that natural products have biochemical properties that make them superior. The title of an article by Harvey *et al.* (2015) is emblematic: "re-emergence of natural products for drug discovery in the age of genomics".

The presumed value of tropical forests' biodiversity for the pharmaceutical industry is predicated on the existence of cutting-edge technologies to identify and understand compounds and their potential uses. This requires strategic alliances involving public and private research organizations. Skirycz et al. (2016) propose that pharmaceutical companies share their chemical libraries through pre-competitive agreements. No one laboratory can seek to know the complete set of chemicals in the rainforest and their uses. Of the 15,000 higher plants estimated to have medicinal properties, less than 200 are currently used in the pharmaceutical industry. Reducing this gap is a scientific task that can give rise to technological innovations. AstraZeneca's chemical library became available to a network of more than 130 research centers (Skirycz *et al.* 2016). The Joint European Compound Libraries also intends to share 500,000 compounds that belong to seven major companies (Besnard *et al.* 2015).

It is essential that Amazonian countries and French Guiana strengthen scientific research, information exchange, and cooperation, at the regional and international level, on biodiversity. It is crucial that mechanisms already established internationally are improved to ensure that populations living in the forest have a fair share in the benefits obtained by research and scientific discoveries (Joly and Santos 2019). Today, these mechanisms do not encourage research, hardly benefit the populations of tropical forests, and do not sufficiently advance scientific knowledge.

30.7.7 State and Local Information Systems

One of the most important premises for the emergence of a new bioeconomy of healthy, standing forests and flowing rivers is that public and private actors are able to count on quality information, not only on production and prices, but also on the social conditions of the territories in which they operate. National statistical bodies' capacity is low when it comes to remote or difficult to access areas. At the same time, it is difficult to develop and comply with development plans in the absence of state and local statistical information. This is a field in which international cooperation, as well as cooperation between Amazonian territories, will play a fundamental role.

30.8 Conclusions

With the greatest socio-biodiversity on the planet, and the accumulated knowledge of at least 12,000 years of human history, the Amazon rainforest, over which eight governments and one overseas territory have sovereignty, has a unique material and spiritual culture, which is a natural patrimony and common good of humanity. The forest (as an ethical value) and the people who inhabit it and contribute to its conservation are the starting point of any project aimed at the emergence of a new bioeconomy in the Amazon.

Strengthening tropical forests' natural and social networks is not justified only for instrumental reasons. Despite the immense utility of its products and services, it is essential that the conservation and regeneration of the Amazon are not merely a means, but an end. However, the ethical value of protecting the forest and its peoples also has a decisive instrumental counterpart; given Latin America's deindustrialization in recent decades, the sustainable use of socio-biodiversity, supported by science and technology, represents one of the most promising ways to reduce the distance that currently separates the region from the scientific and technological frontier of contemporary innovation.

A second guiding approach of this chapter focuses on the knowledge of the socio-environmental reality on which the relationship between society and nature in the Amazon is based. A new bioeconomy of healthy, standing forests and flowing rivers will only emerge if it is part of a broad process of improving the living conditions of those who live in the Amazon. Without this, it would confine itself to an enclave, in a non-propitious environment, unable to offer the goods and services that can be expected of it.

Making tropical forests a vector for the development of life sciences' applications for the whole of humanity is a decisive aspiration. This presupposes that the bioeconomy paves the way not only to valuing the knowledge of those who directly exploit the forest, but also the social emancipation of those who are currently in vulnerable situations.

This dual objective (scientific guidance on the use of forest socio-biodiversity, and forest products and services as a means of combating poverty) needs to be addressed in an organically-articulated manner. Nobody has the recipe for this articulation, but it will surely result from the joint action of forest dwellers, the activists who defend them, organizations that foster entrepreneurship, and urban populations in the transformation of forest products, and social coalitions that may give rise to these transformations. Social change processes as ambitious as the emergence of a new bioeconomy of healthy, standing forests and flowing rivers depend on widespread change in the views of political and economic actors on the predominant forms of their activities.

This presupposes public policies that immediately interrupt the current prevalence of violence, illegality, and destruction in the region. These policies will have to integrate protection of the forest and the use of its products and services with the strengthening of environmentally-sensitive infrastructures aimed at improving the living conditions of the Amazon's inhabitants, and not only today's farming and mineral commodity production activities.

It is important to insist on an innovative methodological option. The great distance between the forest socio-biodiversity economy and what is currently identified as a bioeconomy globally, does not allow that the usual categories are used when tropical forests, and the Amazon in particular, are at stake. Establishing the bioeconomy as the domain par excellence of the life sciences (with an emphasis on the definitions in the introductory section of this chapter) means changing the paradigm that currently drives the overwhelming majority of tropical forest activities, products, and services. At the same time, replacing the current economy of destruction with an economy of knowledge of nature (which involves science and technology) is a fundamental ambition for a new economy of healthy, standing forests and flowing rivers. In other words, although the current forest socio-biodiversity still lacks an important vector for its use in science, this limitation must be overcome to guarantee the sustainable development—and ultimately the survival—of the invaluable Amazonian socioecological systems.

30.9 References

Abdenur AE, Kuele G, and Amorim A. 2019. Clima e segurança na América Latina e Caribe. Instituto Igarapé.

Abdenur A, Ferguson B, Carvalho IS de, *et al.* 2020. Environmental crime in the Amazon Basin: a typology for research, policy and action. Instituto Igarapé.

ABIMCI. 2019. PARICÁ- PLYWOOD. Concept and characteristics of a new alternative.

Abramovay R. 2020a. Amazônia: por uma economia do conhecimento da natureza. Editora Elefante.

Abramovay R. 2020b. Floresta Amazônica: a sociobiodiversidade como valor universal. Available at: https://tab.uol.com.br/colunas/ricardo-abramovay/2020/08/28/amazonia-a-sociobiodiversidade-como-valor-universal.htm

Academia Brasileira de Ciências (ABC). 2008. Amazônia Desafio Brasileiro do século XXI A necessidade de uma revolução científica e tecnológica. São Paulo: Fundação Conrado Wessel São Paulo.

AFIN. 2014. Manejo forestal comunitaria de pueblos indígenas de Bolivia. Santa Cruz, Bolivia: Informe para Forest Trends.

Aguilar A and Patermann C. 2020. Biodiplomacy, the new frontier for bioeconomy. *N Biotechnol* **59**: 20–5.

Albuquerque, IgorAlencar A, Angelo C, Azevedo T, *et al.* 2020. SEEG 8 - Análise das emissões brasileiras de gases de efeito estufa e suas implicações para as metas de clima do Brasil 1970-2019.

Algarve TD, Assmann CE, Cadoná FC, *et al.* 2019. Guarana improves behavior and inflammatory alterations triggered by methylmercury exposure: an in vivo fruit fly and in vitro neural cells study. *Environ Sci Pollut Res* **26**: 15069–83.

Aliança pela restauração na Amazônia. 2020. Panorama e caminhos para a restauração de paisagens florestais na Amazônia. Position paper.

Allkin B. 2017. Useful Plants – Medicines. *State World's Plants 2017*: **8**.

Almeida ZS, Isaac VJ, Santos NB, and Paz AC. 2011. Sustentabilidade dos sistemas de produção pesqueira maranhense. Rio Grande, Brasil: Editora da Furg.

Amaral E. 2009. O Manejo comunitário de pirarucu (Arapaima gigas) como alternativa econômica para os pescadores das RDS's Amanã e Mamirauá, Amazonas, Brasil.

Amazônia Legal em dados. Amazônia Legal em Dados. Visão integrada do território pelos nove estados da Amazônia Legal. Available at: https://amazonialegalemdados.info/home/home.php?regiao=Amazônia Legal https://seeg-. Accessed on: 8 Jun 2021.

AMVCM. 2021. Comunidade – Associação de Moradores Vila Céu do Mápia. Available at: http://vilaceudomapia.org.br/comunidade/. Accessed on:

Angelo C. 2020. Biodiversidade: Países assinam acordo na Rio+10 - UOL Educação. Available at: https://vestibular.uol.com.br/resumo-das-disciplinas/atualidades/biodiversidade-paises-assinam-acordo-na-rio10.htm?next=0003H43U12N&cmpid=copiaecola. Accessed on: 9 Jun 2021.

Angelo H, Calderon R de A, Almeida AN de, *et al.* 2018. Analysis of the non-timber forest products market in the Brazilian Amazon. *Aust J Crop Sci* **12**: 1640–4.

Angelsen A, Brockhaus M, Sunderlin W, and Verchot L. 2012. Analysing REDD+: Challenges and choices. Center for International Forestry Research (CIFOR).

Antonaccio L, Barros AC, Bragança A, and Chiavari J. 2020. A importância em aprimorar a definição e a delimitação da Área de Influência de projetos de infraestrutura. *Clim Policy Initiat*.

Antonelli A, Smith RJ, Fry C, *et al.* 2020. State of the World's Plants and Fungi.

Apapyaú. 2021. Portal Amazônia Legal em Dados reúne de forma inedita dados sobre a região, principais desafios e análises. Available at: https://arapyau.org.br/portal-amazonia-legal-em-dados-reune-de-forma-inedita-dados-sobre-a-regiao-principais-desafios-e-analises/.

Araújo JG, Santos MAS, Rebello FK, and Isaac VJ. 2017. Cadeia comercial de peixes ornamentais do Rio Xingu, Pará, Brasil. *Bol do Inst Pesca* **43**: 297–307.

Arroyo LM and Marchi M De. 2017. Los retos del turismo sostenible en la Amazonia ecuatoriana: Entre políticas públicas y prácticas territoriales. In: Larrea C (Ed). ¿Está agotado el periodo petrolero en Ecuador? Universidad Andina Simón Bolívar.

Associação Brasileira da Psicultura. 2020. Anuário PeixeBR da Psicultura 2020.

Atala A. 2012. A new ingredient: The introduction of priprioca in gastronomy. *Int J Gastron Food Sci* **1**.

Azevedo-Ramos C, Moutinho P, Arruda VL da S, *et al.* 2020. Lawless land in no man's land: The undesignated public forests in the Brazilian Amazon. *Land use policy* **99**: 104863.

Balée W. 2013. Cultural forests of the Amazon: a historical ecology of people and their landscapes. University of Alabama Press.

Barlow J, Berenguer E, Carmenta R, and França F. 2020. Clarifying Amazonia's burning crisis. *Glob Chang Biol* **26**: 319–21.

Barlow, J, França, F, Gardner TA, *et al.* 2018. The future of hyperdiverse tropical ecosystems. *Nature* ***559***: 517-526.

Barrera JA, Giraldo Benevides B, Castro S, *et al.* 2017. Sistemas agroforestales para la Amazonia. Bogotá, Colombia: Instituto Amazónico de Investigaciones Científicas.

Barros AVL De, Homma AKO, Takamatsu JA, *et al.* 2009. Evolução e percepção dos sistemas agroflorestais desenvolvidos pelos agricultores nipo-brasileiros do município de tomé-açu, estado do Pará. *Amaz Ciência Desenvolv* **5**: 121–52.

Basta PC and Hacon S de S. 2020. Impacto do mercúrio na saúde do povo indígena Munduruku, na bacia do Tapajós. WWF and Fiocruz.

Batista VS, Isaac VJ, Fabré NN, *et al.* 2012. Peixes e pesca no Solimões-Amazonas: uma avaliação integrada. Brasilia: Ibama/ProVárzea.

Batista VS, Isaac VJ, and Viana JP. 2004. Exploração e manejo dos recursos pesqueiros da Amazônia (M Rufino, Ed). Ibama/ProVárzea Manaus.

Bebbington A, Chicchon A, Cuba N, *et al.* 2020. Opinion: Priorities for governing large-scale infrastructure in the tropics. *Proc Natl Acad Sci* **117**: 21829–33.

Belém GC de. 2021. Grupo Carta de Belém.

Benevides SLM, Filho F de SP, Madeira MJA, *et al.* 2018. Social Innovation by Tourism Strategy in the Western Amazon. *Int J Adv Eng Res Sci* **5**: 78–92.

Besnard J, Jones PS, Hopkins AL, and Pannifer AD. 2015. The joint european compound library: Boosting precompetitive research. *Drug Discov Today* **20**: 181–6.

Birner R. 2018. Bioeconomy concepts. In: Bioeconomy. Springer, Cham.

Boulding K. 1966. The economics of the coming spaceship earth. In: Jarrett H (Ed). Environmental Quality in a Growing Economy. Resources for the Future/Johns Hopkins University Press.

Brancalion PHS, Almeida DRA de, Vidal E, *et al.* 2018. Fake legal logging in the Brazilian Amazon. *Sci Adv* **4**: eaat1192.

Brancalion PHS, Lamb D, Ceccon E, *et al.* 2017. Using markets to leverage investment in forest and landscape restoration in the tropics. *For Policy Econ* **85**: 103–13.

Brazil. 2020a. Recomendações de Políticas para a Cadeia de Valor da Castanha-do-Brasil.

Brazil. 2020b. Estudo mapeia quantitativo de pesquisadores no Amazonas. Available at: http://www.sedecti.am.gov.br/estudo-mapeia-quantitativo-de-pesquisadores-no-amazonas/.

Brazil. 2021. Política Nacional de Pagamento por Serviços Ambientais. LEI Nº 14.119, DE 13 DE JANEIRO DE 2021. Available at: http://www.planalto.gov.br/ccivil_03/_Ato2019-2022/2021/Lei/L14119.htm.

Brito B, Barreto P, Brandão A, *et al.* 2019. Stimulus for land grabbing and deforestation in the Brazilian Amazon. *Environ Res Lett* **14**: 064018.

Brondizio ES. 2008. The Amazonian Caboclo and the Açaí Palm: Forest Farmers in the Global Market. In: Advances in Economic Botany. New York Botanical Garden Press.

Brondizio ES. 2021. The Global Açaí: A Chronicle of Possibilities and Predicaments of an Amazonian Superfood. In: Critical Approaches to Superfoods. Bloomsbury Publishing Plc.

Bryant D, Nielsen D, and Tangley L. 1997. The Last Frontier Forests: Ecosystems and Economies on the Edge. Washington, DC: World Resources Institute.

Burt RS. 2000. The network entrepreneur. *Entrep Soc Sci view*: 281–307. In: Swedberg R (Ed). The Social Science View. Oxford, UK: Oxford University Press.

Butler RA. 2019. 2019: The year rainforests burned. *Mongabay*.

Brondizio ES, Andersson K, de Castro F, et al. 2021. Making place-based sustainability initiatives visible in the Brazilian Amazon. *Current Opinion in Environmental Sustainability* ***49***: 66-78.

Calderón Á. 2015. Análisis de la Cadena del Turismo. *Com Económica para América Lat y el Caribe-CEPAL Quito-Ecuador*.

Cappucci, M. (2016). Indigenous tourism in the Amazon region of Suriname: actions to preserve authenticity and natural resources. *GeoJournal of Tourism and Geosites* **17:** 47-56.

Carpintero Ó. 2006. La Bioeconomía de Georgescu-Roegen. Montesinos Barcelona.

Castro BS, Young CEF, and Pereira V de S. 2018. Iniciativas Estaduais de Pagamentos por Serviços Ambientais análise legal e seus resultados. *Rev Iberoam Econ Ecológica*: 44–71.

Castro EV, Souza TB, and Thapa B. 2015. Determinants of tourism attractiveness in the national parks of Brazil. *Parks* **21**: 51–62.

Cavalcante PB. 1979. Frutas comestíveis na Amazônia. Museu Paraense Emilio Goeldi.

CBD. 2014. Ecologically or Biologically Significant Marine Areas (EBSAs). Available at: https://www.cbd.int/ebsa/. Accessed on: 29 Jul 2021.

CBD. 2020. Update of the zero draft of the post-2020 global biodiversity framework. *Prep Post-2020 Biodivers Framew* Post2020/P: 1–9.

Cerdeira RGP, Ruffino ML, and Isaac VJ. 1997. Consumo de pescado e outros alimentos pela população ribeirinha do Lago Grande de Monte Alegre, PA-Brasil. *Acta Amaz* **27**: 213–27.

CGEE - Centro de Gestão e Estudos Estratégicos. 2009. Um projeto para a Amazônia no século 21: desafios e contribuições.

CGEE - Centro de Gestão e Estudos Estratégicos. 2013. Plano de Ciência, Tecnologia e Inovação para o Desenvolvimento da Amazônia Legal.

Chiaretti D. 2020a. Questão ambiental tem que escalar 1º plano da política econômica, dizem ex-ministros da Fazenda e ex-presidentes do BC. *Valor Econômico*.

Chiaretti D. 2020b. "Concertação" reúne 100 líderes para "salvar" a Amazônia. *Valor Econômico*.

Chiavari J, Antonaccio L, and Cozendey G. 2020. Regulatory and Governance Analysis of the Life Cycle of Transportation Infrastructure Projects in the Amazon. *Clim Policy Initiat*.

Cho V. 2010. A study of the non-economic determinants in tourism demand. *Int J Tour Res* **12**: 307–20.

CITES. 2021. CITES. https://cites.org/eng.

Clay JW, Sampaio P de TB, and Clement CR. 1999. Biodiversidade amazônica: exemplos e estratégias de utilização. SEBRAE/AM.

Clement CR, Denevan WM, Heckenberger MJ, *et al.* 2015. The domestication of Amazonia before European conquest. *Proc R Soc B Biol Sci* **282**: 20150813.

CNI - Confederação Nacional da Indústria. 2020. Bioeconomia e a Indústria Brasileira / Confederação Nacional da Indústria, Gonçalo Pereira. Brasília: 118p. Available at: https://static.portaldaindustria.com.br/media/filer_public/cd/ed/cded4159-a4c5-474d-9182-dd901b317e1c/bioeconomia_e_a_industria_brasileira.pdf

Coalizão Brasil. 2021. Nota técnica sobre os vetos a lei nº 14.119, que institui a Política Nacional de Pagamento por Serviços Ambientais.

CONAB. 2020. Boletim da Sociobiodiversidade. *Cia Nac Abast* **4**: 1–39.

Concertação pela Amazônia. 2021. Grupo de Bioeconomia da Concertação pela Amazônia. O valor da diversidade para a bioeconomia. Available at: https://pagina22.com.br/uma-concertacao-pela-amazonia

Conexsus. 2020. Negócios pela Tierra. Inteligência de mercado para empreendimentos comunitários.

Coslovsky S. 2021. Oportunidades para Exportação de Produtos Compatíveis com a Floresta na Amazônia Brasileira. Amazônia 2030. Available at: https://amazonia2030.org.br/wp-content/uploads/2021/04/AMZ2030-Oportunidades-para-Exportacao-de-Produtos-Compativeis-com-a-Floresta-na-Amazonia-Brasileira-1-2.pdf

Costa FDA. 2020. Economia camponesa referida ao bioma da Amazônia: atores, territórios e atributos (Edição 476). *Pap do NAEA* **29**.

Costa SMF and Brondízio ES. 2009. Inter-urban dependency among Amazonian cities: urban growth, infrastructure deficiencies, and socio-demographic networks. *Redes (St Cruz Sul, Online)* **14**: 211–34.

Crespi G, Navarro JC, and Zuñiga P. 2010. Science, technology, and innovation in Latin America and the Caribbean: A statistical compendium of indicators.

Costa J Da and Fleury M. 2015. O programa "municípios verdes": estratégias de revalorização do espaço em municípios paraenses. *Ambient Soc* **XVIII**.

Daly HE. 1996. Beyond growth: the economics of sustainable development. Beacon Press.

Dasgupta P. 2021. The economics of biodiversity: the Dasgupta review: www.gov.uk/official-documents.

Del Gatto F, Mbairamadji J, Richards M, and Reeb D. 2018. Small-scale forest enterprises in Latin America: unlocking their potential for sustainable livelihoods. Rome.

de Oliveira AC, Soccol, VT and Rogez, H. 2019. Prevention methods of foodborne Chagas disease: Disinfection, heat treatment and quality control by RT-PCR. *Int J of food microbiology* **301**: 34-40.

Ding, H., Veit, P. G., Blackman, A., Gray, E., Reytar, K., Altamirano, J. C. & Hodgdon, B. 2016. *Climate Benefits, Tenure Costs: The Economic Case for Securing Indigenous Land Rights in the Amazon.* Washington D. C., World Resources Institute (WRI).

Duchelle AE, Greenleaf M, Mello D, *et al.* 2014. Acre's State System of Incentives for Environmental Services (SISA), Brazil. Available at: https://www2.cifor.org/redd-case-book/case-reports/brazil/acres-state-system-incentives-environmental-services-sisa-brazil/#content-chapter.

Duchelle AE, Simonet G, Sunderlin WD, and Wunder S. 2018. What is REDD+ achieving on the ground? *Curr Opin Environ Sustain* **32**: 134–40.

EIA – Environmental Investigation Agency. 2019. Condenando el Bosque. Resumen Ejecutivo. Available at https://static1.squarespace.com/static/5cf808dd6b7c4e0001ba92bd/t/5d13877d560ec50001b40d76/1561560967756/Condenando+el+Bosque+-+Resumen+Ejecutivo.pdf

EMBRAPA. 2020. Estratégia de recuperação Sistemas Agroflorestais – SAFs. Available at: https://www.embrapa.br/en/codigo-florestal/sistemas-agroflorestais-safs.

EMBRAPA. 2021. Projeto Bom Manejo – Fase 2. Available at: https://www.embrapa.br/en/bom-manejo. Viewed

Euler A, Amorim J, Salim A, and Lira-Guedes A. 2019. Paisagem, territorialidade e conhecimento tradicional associado à agrobiodiversidade em comunidades da Amazônia: o caso da comunidade Arraiol do Bailique, Amapá. Embrapa Amapá.

Ezzine-de-Blas D, Wunder S, Ruiz-Pérez M, and Moreno-Sanchez R del P. 2016. Global Patterns in the Implementation of Payments for Environmental Services (A García-Gallego, Ed). *PLoS One* **11**: e0149847.

Fabré NN, Ribeiro MOA, Batista VS, *et al.* 2003. Sistemas abertos sustentáveis (SAS): uma alternativa de desenvolvimento local, integrado, adaptativo e participativo para a Amazônia. *Sist abertos sustentáveis--SAS uma Altern gestão Ambient na Amaz Manaus/AM EDUA*: 39–64.

FAO and FILAC. 2021. Los pueblos indígenas y tribales y la gobernanza de los bosques - Una oportunidad para la acción climática en Latina América y el Caribe. FAO.

Faria PMC, Ribeiro K, Almeida CF, *et al.* 2016. Aquicultura Ornamental: um mercado promissor. *Panor da Aquicultura* **26**: 24–37.

Favareto AS, Galvanese C, and Barufi AM. 2014. A dimensão territorial do desenvolvimento brasileiro recente Brasil (2000-2010).

Fearnside PM. 1999. Biodiversity as an environmental service in Brazil's Amazonian forests: risks, value and conservation. *Environ Conserv* ***26***: 305–21.

Ferreira J, Lennox GD, Gardner TA, *et al.* 2018. Carbon-focused conservation may fail to protect the most biodiverse tropical forests. *Nat Clim Chang* **8**: 744–9.

Fligstein N. 2001a. Social skill and the theory of fields. *Sociol Theory* **19**: 105-125.

Fligstein N. 2001b. The Architecture of Markets. Princeton University Press.

FLORAPLAC. 2020. FLORAPLAC. Available at: http://www.floraplac.com.br/a-floraplac.html

Folke C, Carpenter SR, Chapin F, *et al.* 2020. Our Future in the Anthropocene Biosphere: Global sustainability and resilient societies. *SSRN Electron J*: 0–72.

Frédou T, Figueiredo Filho LD, Torres DG, *et al.* 2008. Diagnóstico, tendência, potencial e políticas públicas para o desenvolvimento da pesca esportiva. In: Diagnóstico da pesca e aquicultura do estado do Pará. Belem, Pa: Secretaria de Estado de Pesca e Aqüicultura.

Freitas NF de and Schor T. 2020. Bioeconomia e a bolsa de mercadorias da Amazônia. *Interess Nac* **13**: 20–5.

Fücks R. 2015. Green growth, smart growth: A new approach to economics, innovation and the environment. Anthem Press.

Futemma C, Castro F De, and Brondizio ES. 2020. Farmers and social innovations in rural development: Collaborative arrangements in eastern Brazilian Amazon. *Land use policy* **99**: 104999.

Gabre-Madhin EZ. 2012. A market for Abdu: creating a commodity exchange in Ethiopia. International Food Policy Research Institute (IFPRI).

Garcez RCS, Souza LA, Frutuoso ME and Freitas CEC. 2017. Seasonal dynamic of Amazonian small-scale fisheries is dictated by the hydrologic pulse, *Bol. Do Inst. Pesca* **43**: 207–221.

Gardner TA, Burgess ND, Aguilar-Amuchastegui N, *et al.* 2012. A framework for integrating biodiversity concerns into national REDD+ programmes. *Biol Conserv* **154**: 61–71.

Garrett RD, Gardner TA, Morello TF, *et al.* 2017. Explaining the persistence of low income and environmentally degrading land uses in the Brazilian Amazon. *Ecol Soc* **22**: art27.

Garrett RD, Ryschawy J, Bell LW, *et al.* 2020. Drivers of decoupling and recoupling of crop and livestock systems at farm and territorial scales. *Ecol Soc* **25**: art24.

GCF. 2021. Protecting forests, reducing emissions, and enhancing livelihoods across 1/3 of the world's tropical forests. Available at: https://www.gcftf.org.

Geels FW, Sovacool BK, Schwanen T, et al. Sociotechnical transitions for deep decarbonization. Science 357:1242-1244.

Georgescu-Roegen N. 2011. Inequality, limits and growth from: A bioeconomic viewpoint (1978). In: From Bioeconomics to Degrowth: Georgescu-Roegen's New Economics in Eight Essays. London, UK: Routledge.

German Bioeconomy Council. 2017. Bioeconomy Policy (Part III). Update Report of National Strategies around the World.

Gomes CV, Ehringhaus C, Dutra CM, *et al.* 2012. Oportunidades de Apoio a Atividades Produtivas Sustentáveis na Amazônia. Internationale Zusammenarbeit (GIZ) GmbH.

Gomes R, Bone S, Cunha M, *et al.* 2010. Exploring the Bottom-up Generation of REDD + Policy by Forest-dependent Peoples. *Policy Matters* ***17:*** 161-168.

Gonzales Rocabado J and Terán Valenzuela M. 2012. La senda de la castaña: Retos para el manejo sostenible de la castaña en diez comunidades del norte amazónico de Bolivia. Fundación PIEB.
Grogan J and Barreto P. 2005. Big-leaf mahogany on CITES Appendix II: big challenge, big opportunity. *Cons Biol* **19**: 973-976.
Gudynas E. 2021. Extractivisms: Politics, Economy and Ecology. Fernwood Publishing.
Guerra R and Moutinho P. 2020. Challenges of Sharing REDD+ Benefits in the Amazon Region. *Forests* **11**: 1012.
Guillen ICM. 2007. O trabalho de Sísifo: "escravidão por dívida" na indústria extrativa da erva-mate (Mato Grosso, 1890-1945). *Varia Hist* **23**: 615–36.
Guimarães J, Amaral P, Pinto A, and Gomes I. 2019.Preços de Produtos da Floresta: uma década de pesquisa e divulgação. Imazon.
Harvey AL, Edrada-Ebel R, and Quinn RJ. 2015. The re-emergence of natural products for drug discovery in the genomics era. *Nat Rev drug Discov* **14**: 111–29.
Hausmann R, Hidalgo CA, Bustos S, *et al.* 2014. The atlas of economic complexity: Mapping paths to prosperity. Mit Press.
Heads of State and Heads of Delegation of the Plurinational State. 2019. Leticia Pact for the Amazon region.
Hern WM. 1991. Health and demography of native Amazonians: historical perspective and current status. *Cad Saude Publica* **7**: 451–80.
Herrfahrdt-Pähle E, Schlüter M, Olsson P, *et al.* 2020. Sustainability transformations: socio-political shocks as opportunities for governance transitions. *Glob Environ Chang* **63**:102097.
Hirakuri SR. 2003. Can law save the forest?: lessons from Finland and Brazil. CIFOR.
Homma AKO, Nogueira OL, Menezes AJEA, *et al.* 2006. Açaí: Novos Desafios E Tendências. *Amaz e Desenvolv* **1**: 7–23.
Homma AKO. 2016. A imigração japonesa na Amazônia: sua contribuição ao desenvolvimento agrícola. Brasília, DF: Embrapa.
Homma AKO. 2016b. Perspectivas de mercado para as fruteiras nativas Amazônicas. In: XXIV Congresso Brasileiro de Fruticultura.
IBGE. 2019. Produção da Extração Vegetal e da Silvicultura - PEVS. *Prod Extr Veg e Silvic, Rio do Janeiro* **34**:1-8.
IBGE. 2019. Censo agropecuário 2017: resultados definitivos. *Censo agropecuário* **8**: 93.
IDAM. 2019. Projeto do Idam para cultura do guaraná pretende aumentar produção e produtividade em seis municípios do interior. Instituto de Desenvolvimento Agropecuário e Florestal Sustentável do Estado do Amazonas.
IDESAM. 2021. Ecopainéis do açaí. Available at: https://aceleracao.ppa.org.br/portfolio-de-negocios/ecopaineis-do-acai/
IFT. 2021. Projetos. Available at: http://www.ift.org.br/projetos/
INPA. 2018. Grupo de Estudos Estratégicos Amazônicos do Inpa debate Piscicultura na Amazônia. Available at: https://www.gov.br/mcti/pt-br/rede-mcti/inpa/.
INPA-INCT. 2021. INCT – Herbário Virtual da Flora e dos Fungos. Herbários/Curadores. Available at: http://inct.florabrasil.net/participantes/herbarios-curadores/ Accessed on October 2021.
Instituto Escolhas. 2019. Uma nova economia para o Amazonas: Zona Franca de Manaus e bioeconomia.
Instuto Escolhas. 2020. A nova corrida do ouro na Amazônia. Onde garimpeiros, instituições financeiras e falta de controle se encontram e avançam sobre a floresta. Instuto Escolhas.
IPS. 2021. Indice de Progresso Social. Available at: http://www.ipsamazonia.org.br/#aspects%5B%5D=1&aspects%5B%5D=2&aspects%5B%5D=9&aspects%5B%5D=15&map-view=city&map-type=performance&active-cat=1&page=1&tab=map
Isaac VJ, Santo RVE, Bentes B, *et al.* 2009. An interdisciplinary evaluation of fishery production systems off the state of Pará in North Brazil. *J Appl Ichthyol* **25**: 244–55.
ITTO – International Tropical Timber Organization. 2019. Biennial review and assessment of the world situation 2017-2018.
IUCN. 2021. IUCN. Available at: https://www.iucn.org.
Jankavski, André. 2020. Santander, Itaú e Bradesco lançam plano conjunto para preservação da Amazônia. *CNN Brazil.* Available at https://www.cnnbrasil.com.br/business/santander-itau-e-bradesco-lancam-plano-conjunto-para-preservacao-da-amazonia.
Jesus RS de, Falcão P de T, Carvalho NL de A, and Carneiro RX. 1991. Técnicas para a conservação e industrialização de pescado na Amazônia. In: Val L, Figliuolo R, Feldberg E (Eds). Bases Científicas para estratégias de preservação e desenvolvimento da Amazônia: fatos e perspectivas. INPA.
Jimenez ÉA, Amaral MT, Souza PL de, *et al.* 2020. Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the amazon coast: A case study in the state of Amapá, Brazil. *Mar Policy* **115**: 103856.
Jobim ML, Barbisan F, Fortuna M, *et al.* 2019. Açai (Euterpe oleracea, Mart.), an Amazonian fruit has antitumor effects on prostate cancer cells. *Arch Biosci Heal* **1**: 61-76.
Joly CA and Santos IL. 2019. Brazilian assessment on biodiversity and ecosystem services: summary for policy makers. *Biota Neotrop*. **19**:e2019086.
Karsenty A, Drigo IG, Piketty M-G, *et al.* 2008. Regulating industrial forest concessions in Central Africa and South America. *For Ecol Manage* **256**: 1498–508.
KFW. 2021. REDD Early Movers (REM) Programme. Available at: https://www.kfw-entwicklungsbank.de/International-financing/KfW-Development-Bank/Topics/Climate/REDD/.
Lennox GD, Gardner TA, Thomson JR, *et al.* 2018. Second rate or a second chance? Assessing biomass and biodiversity recovery in regenerating Amazonian forests. *Glob Chang Biol* **24**: 5680–94.
Lentini M, Sobral L, and Vieira R. 2020. Como o mercado dos produtos madeireiros da Amazônia evoluiu nas últimas duas décadas (1998-2018)? Imaflora.

Leroy B, Dias MS, Giraud E, *et al.* 2019. Global biogeographical regions of freshwater fish species. *J Biogeogr* **46**: 2407–19.
Lewandowski I. 2018. Bioeconomy: Shaping the transition to a sustainable, biobased economy. Springer Nature.
Lima MAL, Kaplan DA, and Rodrigues da Costa Doria C. 2017. Hydrological controls of fisheries production in a major Amazonian tributary. *Ecohydrology* **10**: e1899.
Lopes E, Soares-Filho B, Souza F, *et al.* 2019. Mapping the socio-ecology of Non-Timber Forest Products (NTFP) extraction in the Brazilian Amazon: The case of açaí (Euterpe precatoria Mart) in Acre. *Landsc Urban Plan* **188**: 110–7.
Lopes R, Oliveira M do SP, Cavallari MM, *et al.* 2015. Palmeiras Nativas do Brasil. Embrapa Amazônia Ocidental and Embrapa Informação Tecnológica.
López Hernández V and Schanz H. 2019. Agency in actor networks: Who is governing transitions towards a bioeconomy? The case of Colombia. *J Clean Prod* **225**: 728–42.
Machado AK, Cadoná FC, Assmann CE, *et al.* 2019. Açaí (Euterpe oleracea Mart.) has anti-inflammatory potential through NLRP3-inflammasome modulation. *J Funct Foods* **56**.
Machado M, Carlos EF, and Clauzet M. 2020. Environmental funds to support protected areas: Lessons from Brazilian experiences. *Parks* **26**: 47.
Macqueen DJ, Grieg-Gran M, Lima E, *et al.* 2003. Growing Exports: The Brazilian tropical timber industry and international markets. IIED Small and Medium Enterprise series No. 1. Citeseer.
Magalhães KA, Martins EC, LUCENA CC de, and Holanda Filho ZF. 2018. Panorama da ovinocultura e da caprinocultura a partir do Censo Agropecuário 2017. *Sobral, CE Embrapa Caprinos e Ovinos*.
Maldaner DR, Pellenz NL, Barbisan F, *et al.* 2020. Interaction between low-level laser therapy and Guarana (Paullinia cupana) extract induces antioxidant, anti-inflammatory, and anti-apoptotic effects and promotes proliferation in dermal fibroblasts. *J Cosmet Dermatol* **19**: 629–37.
Mansourian S, Dudley N, and Vallauri D. 2017. Forest Landscape Restoration: Progress in the Last Decade and Remaining Challenges. *Ecol Restor* **35**: 281–8.
MAPA. 2018. Plano Nacional de Desenvolvimento de Florestas. Available at: https://www.gov.br/agricultura/pt-br/assuntos/politica-agricola/outras-publicacoes/plano-nacional-de-desenvolvimento-de-florestas-plantadas.pdf/view
McChesney JD, Venkataraman SK, and Henri JT. 2007. Plant natural products: back to the future or into extinction? *Phytochemistry* **68**: 2015–22.
McGrath D. 1999. Parceiros no crime: o regatão e a resistência cabocla na Amazônia tradicional. *Novos Cad NAEA* **2**: 57–72.
MDIC. 2021. Comex Stat. Available at: http://comexstat.mdic.gov.br/en/home.
Meinhold K and Darr D. 2019. The processing of non-timber forest products through small and medium enterprises—a review of enabling and constraining factors. *Forests* **10**: 1026.
Meira M. 2018. A persistência do aviamento: colonialismo e história indígena no Noroeste Amazônico. EdUFSCar.
Mejía E, Cano W, Jong W de, *et al.* 2015. Actors, harvesting of timber and markets in the Peruvian Amazon. *CIFOR Occas Pap*.
Melo RR de, Menezzi CHS Del, Pavan BE, *et al*. Rotary peeling yield of Schizolobium amazonicum (Leguminosae - Caesalpinioideae). *Acta Amaz* **44**: 315–20.
Mendoza-Cifuentes H, *et al*. 2018. Representatividad de plantas vasculares en los Parques Nacionales Naturales de Colombia: ¿cuántas especies alberga el sistema? *Biota Colombiana* **19**: 21-34.
Montoya-Zumaeta J, Rojas E, and Wunder S. 2019. Adding rewards to regulation: The impacts of watershed conservation on land cover and household wellbeing in Moyobamba, Peru. *PLoS One* **14**: e0225367.
Moreno-Sanchez R, Maldonado JH, Wunder S, and Borda-Almanza C. 2012. Heterogeneous users and willingness to pay in an ongoing payment for watershed protection initiative in the Colombian Andes. *Ecol Econ* **75**: 126–34.
Moutinho P and Guerra R. 2017. Programa REDD para EarlyMovers - REM: Abordagem de estoque e fluxo para a repartição de benefícios em programas de REDD: Conceito e prática na implementação de REDD no estado do Acre. Amazon Environmental Research Institute.
Moutinho P, Martins OS, Christovam M, *et al.* 2011. The emerging REDD+ regime of Brazil. *Carbon Manag* **2**: 587–602.
Moutinho P, Stella O, Lima M, *et al.* 2011. REDD in Brazil: A Focus on the Amazon: Principles, Criteria, and Institutional Structures for a National Program for Reducing Emissions from Deforestation and Forest Degradation--REDD. Center for Strategic Studies and Management.
Murad CA and Pearse J. 2018. Landsat study of deforestation in the Amazon region of Colombia: Departments of Caquetá and Putumayo. *Remote Sens Appl Soc Environ* **11**: 161–71.
NASEM-National Academies of Sciences, Engineering and Medicine. 2020. Safeguarding the Bioeconomy. Washington, D.C.: National Academies Press.
National Academy of Sciences. 1975. Underexploited tropical plants with promising economic value. Washington, DC: National Academy of Sciences.
Natura. 2019. Relatório Anual 2018. Available at: https://static.rede.natura.net/html/2019/a-natura/pdf/relatorio_anual_natura_2018.pdf
Natura. 2020. Relatório Anual 2019. Available at: https://static.rede.natura.net/html/home/2020/br_09/relatorio-anual-2019/relatorio_anual_natura_2019.pdf.
Nepstad D, Moutinho P, Boyd W, *et al.* 2012. Re-Framing REDD+: Unlocking jurisdictional REDD+ as a policy framework for low-emission rural development: research results and recommendations for governments. Amazon Environmental Research Institute.
Notícias Agrícolas. 2020. Marfrig anuncia que tem planos para uma cadeia de produção livre de desmatamento em dez anos. Available at: https://www.noticiasagricolas.com.br/noticias/boi/264524-marfrig-anuncia-que-tem-planos-para-uma-cadeia-de-producao-livre-de-desmatamento-em-dez-ano.
Ochoa-Zuluaga GI. 2019. Influencias del turismo global sobre el territorio amazónico. *Bitácora Urbano Territ* **29**: 127–34.

Origens Brasil. 2021. Selo Origens Brasil:https://www.origensbrasil.org.br/.

Padulosi S, Roy P, and Rosado-May FJ. 2019. Supporting Nutrition-Sensitive Agriculture through Neglected and Underutilized Species Operational Framework. IFAD.

Pagiola S, Honey-Rosés J, and Freire-González J. 2016. Evaluation of the permanence of land use change induced by payments for environmental services in Quind{\'\i}o, Colombia. *PLoS One* **11**: e0147829.

Paletto A, Biancolillo I, Bersier J, *et al.* 2020. A literature review on forest bioeconomy with a bibliometric network analysis. *J For Sci* **66**: 265–79.

Palmer C, Taschini L, and Laing T. 2017. Getting more 'carbon bang'for your 'buck'in Acre State, Brazil. *Ecol Econ* **142**: 214–27.

Pascual U, Phelps J, Garmendia E, *et al.* 2014. Social equity matters in payments for ecosystem services. *Bioscience* **64**: 1027–36.

Passet R. 1996. L'économique et le vivant. In: Hors collection. Economica (programme ReLIRE)

Perez C. 2015. The new context for industrializing around natural resources: an opportunity for Latin America (and other resource rich countries)? The Other Canon and Tallin University of Technology Working Papers in Technology Governance and Economic Dynamics.

Pesce, C. 1941. Oleaginosas da Amazônia. Belem, Brasil: Museu Paraense Emílio Goeldi.

Peskett M. 2020. SeeTree's 'intelligence network for trees' gains US$3mn from Orbia Ventures. *Food and Farming Technology.*

Phillips OL and Brienen RJW. 2017. Carbon uptake by mature Amazon forests has mitigated Amazon nations' carbon emissions. *Carbon Balance Manag* **12**: 1–9.

Pinaya WHD, Lobon-Cervia FJ, Pita P, *et al.* 2016. Multispecies Fisheries in the Lower Amazon River and Its Relationship with the Regional and Global Climate Variability (M Castonguay, Ed). *PLoS One* **11**: e0157050.

Pinto A and Cagliari A. 2020. Fundos que administram US$ 4,1 tri em ativos pressionam Brasil a combater desmatamento. *Folha São Paulo*.

Pinto E. 2016. O papel do Pagamento por Servicos Ambientais conforme a realidade de diferentes Perfis de Agricultores familiar da Amazônia.

Piponiot C, Rödig E, Putz FE, *et al.* 2019. Can timber provision from Amazonian production forests be sustainable? *Environ Res Lett* **14**: 064014.

Plotkin MJ. 2020. The Amazon: What Everyone Needs to Know. Oxford University Press, USA.

PNUMA, OCTA, and CIUP. 2009. GEO Amazonía: Perspectivas del medio ambiente en la Amazonía.

Porro R, Miller RP, Tito MR, *et al.* 2012. Agroforestry in the Amazon Region: A Pathway for Balancing Conservation and Development. In: Nair P, Garrity D (Eds). Agroforestry - The Future of Global Land Use. Advances in Agroforestry. Dordrecht: Springer Science.

Prist PR, Levin N, Metzger JP, *et al.* 2019. Collaboration across boundaries in the Amazon. *Science* **366**: 699–700.

PromPeru. 2019. Perfil del vacacionista nacional 2019. Available at: https://www.promperu.gob.pe/TurismoIN//sitio/VisorDocumentos?titulo=Perfil del vacacionista nacional&url=/Uploads/infografias/1086/Perfil del Vacacionista Nacional 2019.pdf&nombObjeto=Infografías&back=/TurismoIN/sitio/Infografias&issuuid=0.

Queiroz HL and Peralta N. 2006. Reserva de Desenvolvimento Sustentável: Manejo integrado dos recursos naturais e gestão participativa. *Dimens humanas da biodiversidade*: 447–76.

Quintana Arias RF. 2018. Turismo, Ambiente y Desarrollo Indígena en el Amazonas Colombiano. *Estudios y Perspectivas en Turismo*. **27**: 460-486.

RAISG. 2020. Amazonia under pressure. Available at: https://atlas2020.amazoniasocioambiental.org/en

Resque A, Coudel E, Piketty M-G, *et al.* 2019. Agrobiodiversity and Public Food Procurement Programs in Brazil: Influence of Local Stakeholders in Configuring Green Mediated Markets. *Sustainability* **11**: 1425.

Ribeiro FAN. 2014. A economia política do mercado verde na Amazônia indígena: a parceria Amazoncoop-The Body Shop sob a perspectiva do etnodesenvolvimento. *Tellus **16***: 57–80.

Richardson VA and Peres CA. 2016. Temporal decay in timber species composition and value in Amazonian logging concessions. *PLoS One* **11**: e0159035.

Rodrigues ASL, Ewers RM, Parry L, *et al.* 2009. Boom-and-Bust Development Patterns Across the Amazon Deforestation Frontier. *Science* **324**: 1435–7.

Rodrigues CGO. 2018. Turismo e uso público. In: Young CEF, Medeiros R (Eds). Quanto vale o verde: a importância econômica das unidades de conservação brasileiras. Conservação Internacional.

Rodríguez AG, Rodrigues M dos S, and Sotomayor Echenique O. 2019. Towards a sustainable bioeconomy in Latin America and the Caribbean: Elements for a regional vision.

Romanelli JP and Boschi RS. 2019. The legacy of elinor ostrom on common forests research assessed through bibliometric analysis. *Cerne* **25**.

Romeiro V, Pinheiro B, Genin C, *et al.* 2020. A new economy for a new era: Elements for building a more efficient and resilient economy in brazil.

Ruffino ML. 2014. Status and trends of the fishery resources of the Amazon Basin in Brazil. *In Fish Evol Manag case Stud from four Cont FAO Tech Pap*: 1–19.

Sadovy de Mitcheson Y, To AW, Wong NW, *et al.* 2019. Emerging from the murk: threats, challenges and opportunities for the global swim bladder trade. *Rev Fish Biol Fish* **29**: 809–35.

Saes MSM, Silva V-L, Nunes R, and Gomes TM. 2014. Partnerships, learning, and adaptation: A cooperative founded by Japanese immigrants in the Amazon rainforest. *Int J Bus Soc Sci* **5**.

Salazar BM. 2011. List of Peruvian CITES Species Wild Flora. Ministerio del Ambiente, Lima, 130p.

Sanchez PA and Tsao JF. 2015. Construcción de estadísticas de turismo de naturaleza: informe consolidado de directorio

de establecimientos - prestadores de servicios turísticos del sector turismo de naturaleza.
Sant'Anna AA and Young CEF. 2010. Direitos de propriedade, desmatamento e conflitos rurais na Amazônia. *Econ Apl* **14**: 381–93.
Santos D, Salomão R, and Veríssimo A. 2021. Fatos da Amazônia 2021. *Imazon*: 86.
Santos IS, Salim S, and Pereira PCG. 2018. Caracterização do reflorestamento de Paricá na microrregião de Paragominas-PA. *Rev Agroecossistemas* **10**: 145–58.
Sasson A and Malpica C. 2017. Bioeconomy in Latin America. *N Biotechnol* **40**: 40–5.
Schmid M. 2019. Quem irá salvar o setor florestal (e como)? Available at: https://www.forest2market.com/blog/br/quem-ira-salvar-o-setor-florestal-e-como. Acessed on:
Schmidt IB, Urzedo DI, Piña-Rodrigues FCM, *et al.* 2019. Community-based native seed production for restoration in Brazil – the role of science and policy (H Pritchard, Ed). *Plant Biol* **21**: 389–97.
Schultes RE. 1979. The Amazonia as a source of new economic plants. *Econ Bot* **33**: 259–66.
Schultes RE and Reis SE von. 1995. Ethnobotany: Evolution of a Discipline. Portland, Ore: Dioscorides Press.
Secretariat of Science and Technology of Amazonas. 2021. Inova SocioBio Project. Available at: http://www.sedecti.am.gov.br/wp-content/uploads/2021/02/Apresentacao-curta-INOVASOCIOBIO-AMAZONAS-11-02-2021.pdf.
Setzer A. 2019. Resumo do evento da tarde escura em São Paulo, 20/Agosto/2019 e sua relação com as nuvens das queimadas. INPE/Programa Queimadas/CPTEC. Available at: https://www.oeco.org.br/wp-content/uploads/2019/08/EventoNuvemEscuridaoFumaca_SaoPaulo_SP-1.pdf
Shanley P, Medina G, Cordeiro S, and Imbiriba M. 2005. Frutíferas e plantas úteis na vida amazônica. Cifor.
Silva Junior CHL, Heinrich VHA, Freire ATG, *et al.* 2020. Benchmark maps of 33 years of secondary forest age for Brazil. *Sci Data* **7**: 269.
Silveira E. 2019. Crise dos mais antigos centros de pesquisa da Amazônia ameaça proteção da Floresta. BBC. Available at: https://www.bbc.com/portuguese/brasil-50396127.
Simonet G, Subervie J, Ezzine-de-Blas D, *et al.* 2019. Effectiveness of a REDD+ project in reducing deforestation in the Brazilian Amazon. *Am J Agric Econ* **101**: 211–29.
Sinclair D and Jayawardena C. 2003. The development of sustainable tourism in the Guianas. *Int J Contemp Hosp Manag* **15**:402-407.
Sinclair D and Jayawardena C 2010. Tourism in the Amazon: identifying challenges and finding solutions. *Worldw Hosp Tour Themes* **2**: 124–135.
Sist P, Piponiot C, Kanashiro M, *et al.* 2021. Sustainability of Brazilian forest concessions. *For Ecol Manage* **496**: 119440.
Skirycz A, Kierszniowska S, Méret M, *et al.* 2016. Medicinal bioprospecting of the Amazon rainforest: a modern Eldorado? *Trends Biotechnol* **34**: 781–90.
Sousa RGC, Souza LA, Frutuoso ME, and Freitas CEDC. 2017. Seasonal dynamic of Amazonian small-scale fisheries is dictated by the hydrologic pulse. *Bol do Inst Pesca* **43**: 207–21.
Sousa RL de, Miranda AU da S, Cordeiro YEM, and Pereira M das G. 2019. Extração e comercialização do óleo de andiroba ("Carapa guianensis" Aublet.) na comunidade da Ilha das Onças, no município de Barcarena, Pará, Brasil. *Interações (Campo Gd)* **20**: 879–89.
Sousa ALP, Maciel LAM and Rodrigues LRR. 2018. Estudo da comercialização de peixes ornamentais da família Loricariidae (Siluriformes) em Santarém/PA. *PubVet* **12**:1-7.
Stickler C, Duchelle AE, Nepstad D, and Ardila JP. 2018. Subnational jurisdictional approaches. *Transform REDD*: 145.
Strassburg BBN, Iribarrem A, Beyer HL, *et al.* 2020. Global priority areas for ecosystem restoration. *Nature* **586**: 724–9.
Streck C. 2020. Who Owns REDD+? Carbon markets, carbon rights and entitlements to REDD+ finance. *Forests* **11**: 959.
Sunderlin WD, Pratama CD, Bos AB, *et al.* 2014. REDD+ on the ground: The need for scientific evidence. CIFOR.
Sunderlin WD, Ekaputri AD, Sills EO, *et al.* 2014. The challenge of establishing REDD+ on the ground: Insights from 23 subnational initiatives in six countries. CIFOR.
Tafner Junior AW and Silva FC. 2011. A história emblemática da cooperativa agrícola mista de Tomé Açu no Nordeste Paraense. In: IX Congresso Brasileiro de História Econômica 10ª Conferência Internacional de História de Empresa, 2011, Curitiba. IX.
Tavares-dias M, Lemos JRG, Martins M, *et al.* 2009. Metazoan and protozoan parasites of freshwater ornamental fish from Brazil. In: Tavares-Dias M (Ed). Manejo e Sanidade de Peixes em Cultivo. Embrapa Amapá, Macapá.
Tedesco PA, Beauchard O, Bigorne R, *et al.* 2017. A global database on freshwater fish species occurrence in drainage basins. *Sci data* **4**: 1–6.
Schroeder P, Anggraeni K, and Weber U. 2019. The Relevance of Circular Economy Practices to the Sustainable Development Goals. *J Ind Ecol* **23**: 77–95.
Trase. 2020. The state of forest risk supply chains. Transparency for Sustainable Economies. Stockholm Environment Institute and Global Canopy.
Tregidgo D, Barlow J, Pompeu PS and Parry L. 2020. Tough fishing and severe seasonal food insecurity in Amazonian flooded forests. *People and Nature* 2:468-482.
TRIDGE. 2020. Brazil Nut global production and top producing countries – Tridge. Available at: https://www.tridge.com/intelligences/brazil-nut/production.
Tunçer B and Schroeder P. 2017. Sambazon: creating environmental and social value through marketing the açaí berry; sustainable agro-forestry practices in the Brazilian Amazon. In: System Innovation for Sustainability 3. Routledge.
UEA. 2020. Bioeconomia: UEA lança a 1ª Escola de Negócios da Floresta Amazônica. Available at: http://www.amazonas.am.gov.br/2020/11/bioeconomia-uea-lanca-a-1a-escola-de-negocios-da-floresta-amazonica/.

Valente LMM. 2006. Unha-de-gato [Uncaria tomentosa (Willd.) DC. e Uncaria guianensis (Aubl.) Gmel.]: Um Panorama Sobre seus Aspectos mais relevantes. *Fitos* **2**: 48–58.

Valli M, Russo HM, and Bolzani VS. 2018. The potential contribution of the natural products from Brazilian biodiversity to bioeconomy. *An Acad Bras Cienc* **90**: 763–78.

Vatican. 2019. Amazônia: novos caminhos para a Igreja e para uma ecologia integral. In: Assembleia Especial para a Região Panamazônica.

Veiga JE da. 2003. Cidades imaginárias: o brasil é menos urbano do que se calcula. In: GEOUSP: Espaço e Tempo (Online).

Veríssimo A and Pereira D. 2014. Produção na Amazônia Florestal: características, desafios e oportunidades. *Parcer Estratégica* **19**: 13–44.

Viana JP, Castello L, Damasceno JMB, *et al.* 2007. Manejo Comunitário do Pirarucu Arapaima gigas na Reserva de Desenvolvimento Sustentável Mamirauá - Amazonas, Brasil. In: Áreas Aquáticas Protegidas como Instrum gestão pesqueira. Brasilia, DF:IBAMA.

Vieira ICG, Galatti U, and Amaral DD do. 2011. O amazônida Samuel Soares de Almeida (1958-2011). *Bol do Mus Para Emílio Goeldi Ciências Nat* **6**: 209–13.

Vietmeyer N. 2008. Underexploited tropical plants with promising economic value: The last 30 years. *Trees Life J* **3**: 1–13.

Villa Nova LS. 2020. Promoção de bioeconomia da sociobiodiversidade amazônica: o caso da Natura Cosméticos S.A com comunidades agroextrativistas na região do Baixo Tocantins no Pará.

West TAP, Börner J, Sills EO, and Kontoleon A. 2020. Overstated carbon emission reductions from voluntary REDD+ projects in the Brazilian Amazon. *Proc Natl Acad Sci* **117**: 24188–94.

Wilson EO. 1987. The arboreal ant fauna of Peruvian Amazon forests: a first assessment. *Biotropica*: 245–51.

Wunder S. 2015. Revisiting the concept of payments for environmental services. *Ecol Econ* **117**: 234–43.

Wunder S, Börner J, Tito MR, and Pereira LS. 2009. Pagamentos por serviços ambientais: perspectivas para a Amazônia Legal.

Wunder S, Duchelle AE, Sassi C de, *et al.* 2020. REDD+ in theory and practice: how lessons from local projects can inform jurisdictional approaches. *Front For Glob Chang* **3**: 11.

WWF. 2020. Mundurukus têm saúde afetada por mercúrio. Available at: https://www.wwf.org.br/informacoes/noticias_meio_ambiente_e_natureza/?77388/Mundurukus-tem-saude-afetada-por-mercurio, accessed on: January 2021.

WWF and ICMBio. 2017. Biodiversidade Amazônica sob ameaça pela contaminação de mercúrio. Available at: https://www.wwf.org.br/?60322/Biodiversidade-Amaznica-sob-ameaa-pela-contaminao-de-mercrio

Yang Y, Saatchi SS, Xu L, *et al.* 2018. Post-drought decline of the Amazon carbon sink. *Nat Commun* **9**: 1–9.

Young CEF, Alvarenga M, Mendes FE, *et al.* 2019. Valoração de bens e serviços ecossistêmicos associados a projetos de recuperação e conservação ambiental no reservatório de Três Irmãos: carbono, uso público e recursos pesqueiros. In: Anais da Conferência Ibero-Brasileira de Energia – CONIBEN Lisboa. 1º. IBEROJUR.

Zacarkim CE, Piana PA, Baumgartner G, and Aranha JMR. 2015. The panorama of artisanal fisheries of the Araguaia River, Brazil. *Fish Sci* **81**: 409–16.

Zehev B and Vera A. 2015. Ornamental Fishery in Rio Negro (Amazon region), Brazil: Combining Social, Economic and Fishery Analyses. *Fish Aquac J* **6**: 1000143

Zu Ermgassen EK, Ayre B, Godar J, *et al.* 2020. Using supply chain data to monitor zero deforestation commitments: an assessment of progress in the Brazilian soy sector. *Environmental Research Letters* **15**: 035003.

Amazon Assessment Report 2021

Chapter 31

Strengthening land and natural resource governance and management: Protected areas, Indigenous lands, and local communities' territories

Manifestação dos indígenas na Esplanada dos Ministérios em Brasília (Foto: Yanahin Waurá/Amazônia Real

INDEX

GRAPHICAL ABSTRACT **2**

KEY MESSAGES **3**

ABSTRACT **4**

31.1. INTRODUCTION **4**

31.2. INSPIRING SOLUTIONS PATHWAYS **12**

31.2.1. LIFE PLANS AND TERRITORIAL AND ENVIRONMENTAL MANAGEMENT PLANS 13
31.2.2. INDIGENOUS TERRITORIAL MANAGEMENT IN THE GREATER MADIDI LANDSCAPE 15
31.2.3. ASSETS-BASED QUALITY OF LIFE PLANNING AND INTEGRATED TERRITORIAL MANAGEMENT FOR THE ANDES-AMAZON REGION 16
31.2.4. MACRO-TERRITORY OF THE PEOPLE OF YURUPARI (DEPARTMENTS OF VAUPÉS AND AMAZONAS, COLOMBIA): TRADITIONAL KNOWLEDGE AS A BASIS FOR TERRITORIAL MANAGEMENT TO CONSOLIDATE A CONSERVATION MODEL 18
31.2.5. AUTONOMOUS COMMUNITY CONSENT PROTOCOLS BY INDIGENOUS, AFRO-DESCENDANT, AND LOCAL PEOPLES 20
31.2.6. COLLECTIVE FISHING AGREEMENTS AND CO-MANAGEMENT OF PIRACURU FISHERIES IN AMAZONAS STATE, BRAZIL 22
31.2.7. RECREATIONAL FISHING AND TERRITORIAL MANAGEMENT IN INDIGENOUS LANDS, AMAZONAS, BRAZIL 23

31.3. DISCUSSION **25**

31.4. CONCLUSIONS **27**

31.5. RECOMMENDATIONS **28**

31.6 REFERENCES **29**

Graphical Abstract

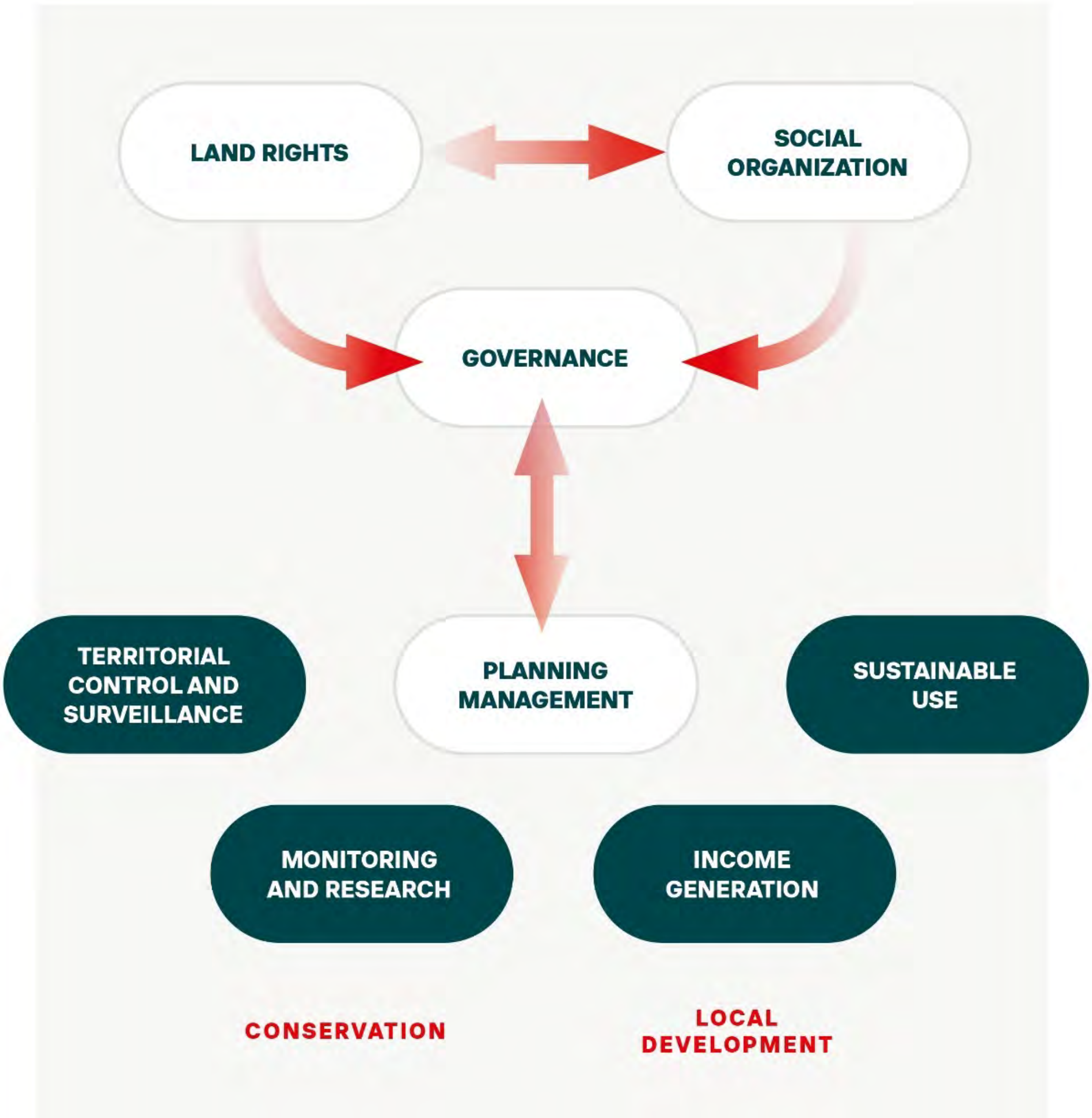


Figure 31.A Graphical Abstract

Strengthening Governance and Management of Lands and Natural Resources: Protected Areas, Indigenous Lands, and Local Communities' Territories

Henyo Trindade Barretto Filho[a], Adriana Ramos[b], Camila Sobral Barra[c], Marivelton Barroso[d], Bibiana Bilbao[e], Patrick Caron[f], Luis Donisete Benzi Grupioni[g], Martin von Hildebrand[h], Christopher Jarrett[i], Davi Pereira Junior[j], Paulo Moutinho[k], Lilian Painter[l], Henrique dos Santos Pereira[m], Carlos Rodríguez[n]

Key Messages

This report has clearly demonstrated the macro-regional context of the direct relationship between, on the one hand, the increasingly critical role of protected areas (including Indigenous lands and local communities' territories) in conserving biodiversity, curbing deforestation, sustaining regional climate stability, supporting local agro-extractivist conservation-friendly economies, and protecting land rights in the Amazon Basin; and, on the other hand, the growing threats and pressures these areas suffer from political and economic interests on the region's resources. This chapter elaborates the following key messages:

- Conservation-friendly livelihoods and creative alternatives are based and dependent on respect for the territorial rights of Indigenous and traditional peoples and communities in the Amazon.
- Strengthening legislation (regulatory frameworks) and institutional procedures (surveillance and law enforcement) that protect Indigenous and traditional peoples' and communities' land and water rights is critical for social justice and conservation outcomes.
- Acknowledging and valuing Indigenous and local knowledge regimes and territorial autonomy as guidelines for conservation action is key.
- The conservation and sustainable management objectives of protected areas, Indigenous lands, and traditional peoples' and communities' territories should be incorporated into investment plans, sectoral legislation, and policies.
- No territory is an island; multi-scale connections between municipalities, departments, Indigenous lands, and traditional peoples' and communities' territories should be strengthened.
- Capillary financial models should be progressively built to enable autonomous and local management of territories and resources with effective participation of Amazonian peoples and communities.
- Organizational strengthening of local social actors for participatory territorial management and development, and integration with public policies is needed and valuable.

[a] Universidade de Brasília, Instituto de Ciências Sociais, Departamento de Antropologia, Centro Sobreloja B1-347, Brasília DF 70910-900, Brasil, henyo.barretto@gmail.com

[b] Instituto Sócio Ambiental, SCLN 210 Bloco C sala 112, Brasília DF 70862-530, Brasil, adriana@socioambiental.org

[c] Consultoria para Negócios Comunitários e Gestão Territorial, Brasil

[d] Federação das Organizações Indígenas do Rio Negro (FOIRN), Av. Alvaro Maia 79, Centro, São Gabriel da Cachoeira 69750-000, Brasil

[e] Universidad Simón Bolívar, Cl. 58 #55-132, Barranquilla, Atlántico, Colômbia

[f] CIRAD/University of Montpellier, Avenue Agropolis, 34398 Montpellier Cedex 5, França

[g] Instituto de Pesquisa e Formação Indígena (IEPÉ), R. Leopoldo Machado 640, Laguinho, Macapá AP 68908-120, Brasil

[h] Fundacion Gaia Amazonas, Calle 70A #11-30, Bogotá, Colômbia

[i] Field Museum, 1400 S Lake Shore Dr, Chicago IL 60605, USA

[j] University of Texas at Austin, 110 Inner Campus Drive, Austin TX 78705, USA

[k] Amazon Environmental Research Institute (IPAM), Av. Rômulo Maiorana 700, Torre Vitta Office sala 1011, Bairro Marco, Belém PA 66093-672, Brasil

[l] Wildlife Conservation Society, C. Gabino Villanueva Nº 340, Entre 24 y 25 de Calacoto Casilla, 3 - 35181 SM, Bolívia

[m] Universidade Federal do Amazonas, Av. General Rodrigo Octavio Jordão Ramos 1200, Coroado I, Manaus AM 69067-005, Brasil

[n] Tropenbos Colombia, Diagonal 46 No. 20-64, Bogotá, Colombia

Abstract

Protected areas, Indigenous lands, and local communities' territories cover a large proportion of the Amazon Basin. These lands play a crucial role in holding back deforestation, maintaining regional climate stability, mitigating global climate change, and — above all — protecting land rights. However, land rights in the Amazon are at critical risk from political interests that drive land profiteering, agribusiness expansion, and illegal logging and mining, with a consequent increase in deforestation rates, in addition to threats to change legislation on territorial rights. The Amazon has no future without uplifting the voices and rights of its peoples and their territorial lifestyles, and promoting conservation-friendly creative alternatives based on the full respect and strengthening of territorial rights.

Keywords: Protected areas, Indigenous lands, communal territories, territorial rights, rights-based conservation management

31.1. Introduction

Protected areas, Indigenous lands, and local communities' territories cover a large proportion of the Amazon Basin (Figure 31.1, Table 31.1). Therefore, strengthening their management for the benefit of their rightful holders represents a unique opportunity for the conservation of Amazonian ecosystems and the biome.

In this chapter, we consider territory as more than a material base and/or production factor, but also as a home for life, where communities and peoples live with security and free access to the places and resources they manage according to their local knowledge practices, incorporating techno-scientific innovations as relevant.

As already discussed in previous chapters, protected areas, Indigenous lands, and land held by other local peoples and communities (under different legal regimes of tenure rights) cover 47.2% of the Amazon.[1]

These territories are crucial for safeguarding both the land rights and well-being of the peoples and communities that live in them (and that have traditionally occupied this vast region), and in preventing and buffering the effects of deforestation, maintaining a stable regional climate, and mitigating global climate change. At the same time, land rights in the Amazon are being threatened by political interests related to conventional frontier economics and extractive industries typical of a regime of capitalist accumulation by dispossession (Harvey, 2003; Barretto F, 2020a,b) — land grabbing, illegal logging, mineral prospecting, agribusiness, and infrastructure expansion — relatively well-represented in the national governments of Amazonian countries. Current drivers of deforestation are the modern counterparts of historically rampant predatory behavior of elites towards the region's resources, always seeing the region as their nations' warehouse — a pattern some label "internal colonialism" (Gonzalez Casanova 1965).

These political and economic drivers do not act in a vacuum, but through discursive paradigms that try to morally justify their particular interests and national ones, as is the case of Alan García's theory of the *perro del hortelano* ("dog-in-the-manger") (García Perez 2007; and for a qualified criticism, Garcia Llorens 2008). The former President of Peru and other leaders have not hesitated in engaging in discourse that there is too much land for too few Indians.

These more- or less-formally acknowledged and protected territories play a fundamental role in the conservation of the Amazon and provide the foundation for a series of diverse initiatives that cultivate both biological and cultural diversity and sustainable management. As importantly, all the "traditionally occupied lands"; as they are generally referred to in Brazil, in a syntax that intertwines culture, politics, and struggle for rights; are the foundations of a series of territorially- and ecologically-based cultural and ethnic identities, which struggle through social movements to

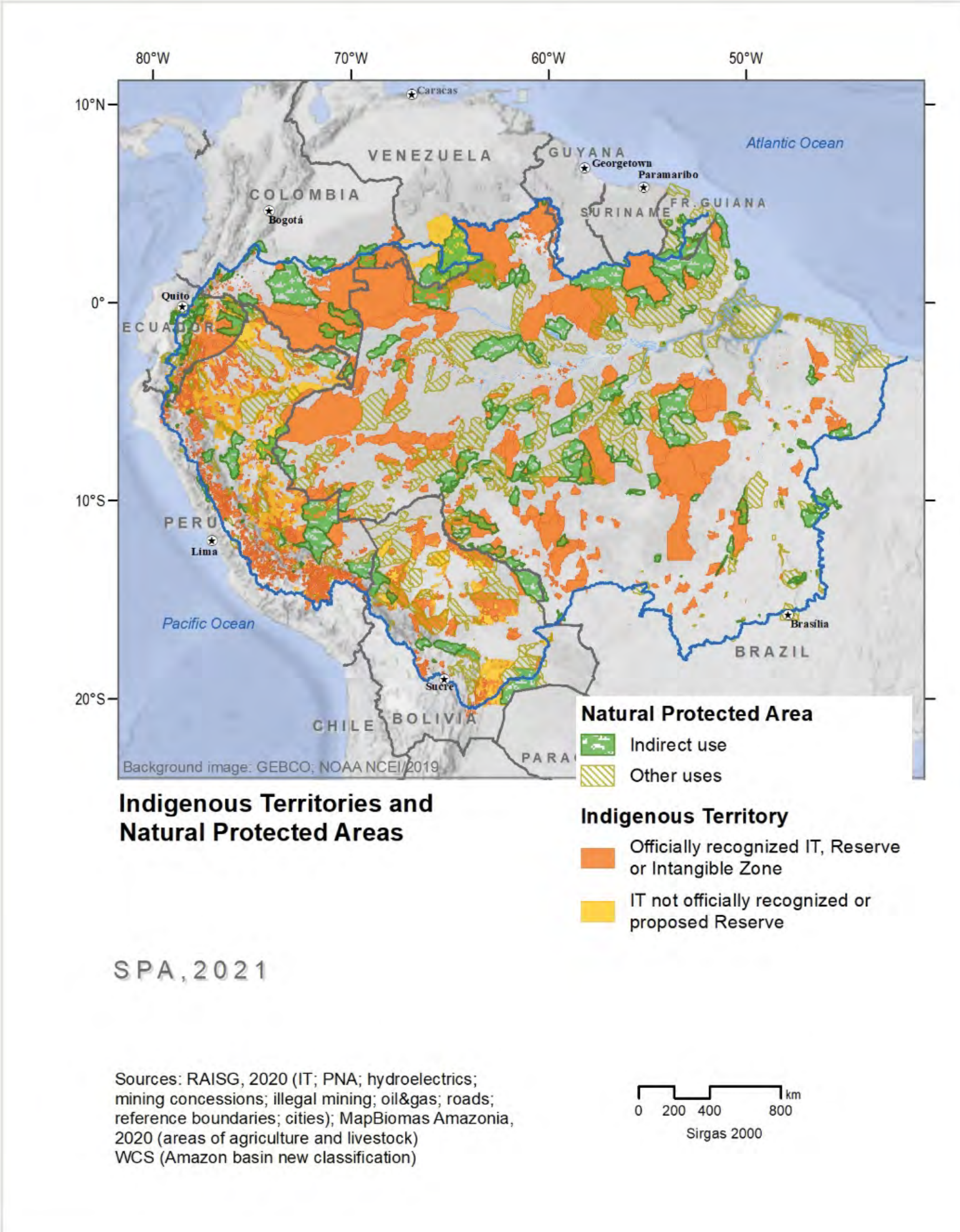


Figure 31.1 Indigenous Territories and Natural Protected Areas

Table 31.1. Coverage of Protected Natural Areas in the Amazon Basin

Territorial Unit	Number of Protected Natural Areas	Protected Surface Area without overlap (km²)[0]	Distribution of total protected area in the Amazon Basin (%)	Percentage of the Amazon Basin area in each country set aside as protected area
Bolivia	81	216,322	11.9	30.3
Brazil	340	1,226,241	67.4	24.3
Colombia	39	89,091	4.9	26.0
Ecuador	26	35,487	2.6	26.8
French Guiana	5	12,685	0.7	50.7
Peru	66	203,916	11.2	21.1
Venezuela	6	23,838	1.3	46.0
Amazon Basin	563	1,819,368	100.0	24.9

	Percentage %							
ANP	**Bolivia**	**Brazil**	**Colombia**	**Ecuador**	**French Guiana**	**Peru**	**Venezuela**	**Amazon Basin**
National total	14.1	13.2	25.7	26.3	51.5	17.8	50.7	15.1
Indirect use	6.8	6.6	25.5	26.3	41.0	10.7	50.7	8.8
Indirect/direct use	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Direct Use	6.8	6.6	0.2	0.0	10.5	6.5	0.0	6.1
Departmental total	16.7	11.8	0.3	0.5	0.0	3.2	0.0	10.2
Indirect Use	0.0	2.6	0.3	0.5	0.0	0.0	0.0	1.8
Direct Use	16.7	9.2	0.0	0.0	0.0	3.2	0.0	8.4
Total	**30.7**	**25.0**	**26.0**	**26.8**	**51.5**	**20.9**	**50.7**	**25.3**

maintain or regain their existential ties to land (Almeida 1994, 2008). Not surprisingly, some Indigenous peoples' movements in Latin America use the term "death projects" (*proyectos de muerte*) to refer to the economic and political enterprises that seriously threaten the integrity and maintenance of their territories (Hernández 2018; Ontiveros *et al*. 2018). Figures 31.2, 31.3, and 31.4 provide a panoramic view of the types and scopes of the threats in the Amazon, as far as agriculture (crops and ranching), hydroelectric plants, mining (illegal and legal), roads, and oil and gas blocks are concerned.

Given the low government investment in infrastructure and in the protection and consolidation of these diverse territories (whether they are parks, reserves, Indigenous lands, or traditionally occupied lands), the most creative and effective strategies for protection and management come from the peoples and communities that live in them, autonomously, regardless of connection to government initiatives or the contribution of civil society organizations in collaboration with different official agencies.

These initiatives are developed as part of the exercise of the right to self-determination of such peo-

[0] Values obtained by calculation with a geographic information system, using Sinusoidal projection, with meridian of -60.

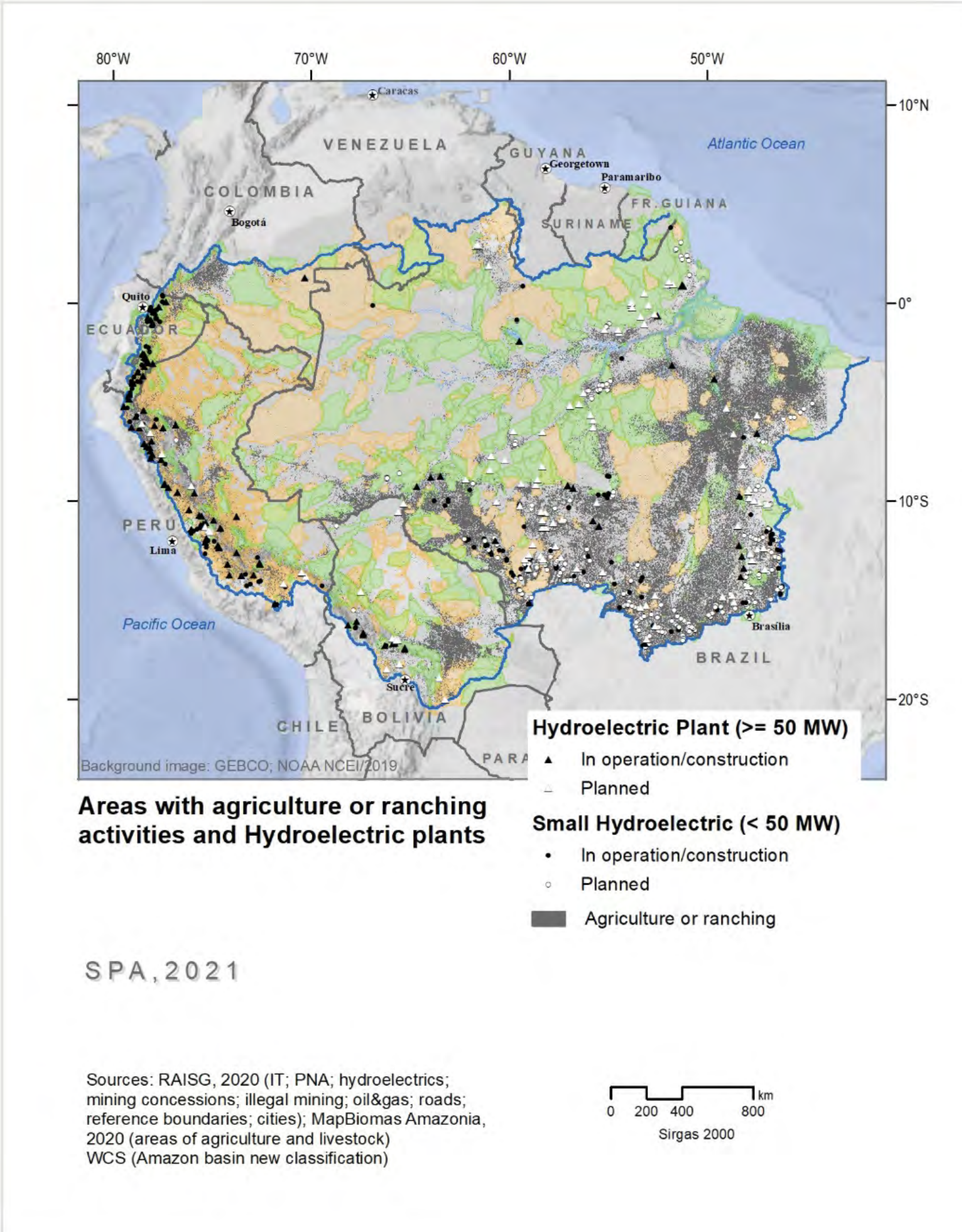


Figure 31.2 Agriculture/ranching activities and hydroelectric plants in the Amazon. Source: RAISG 2020

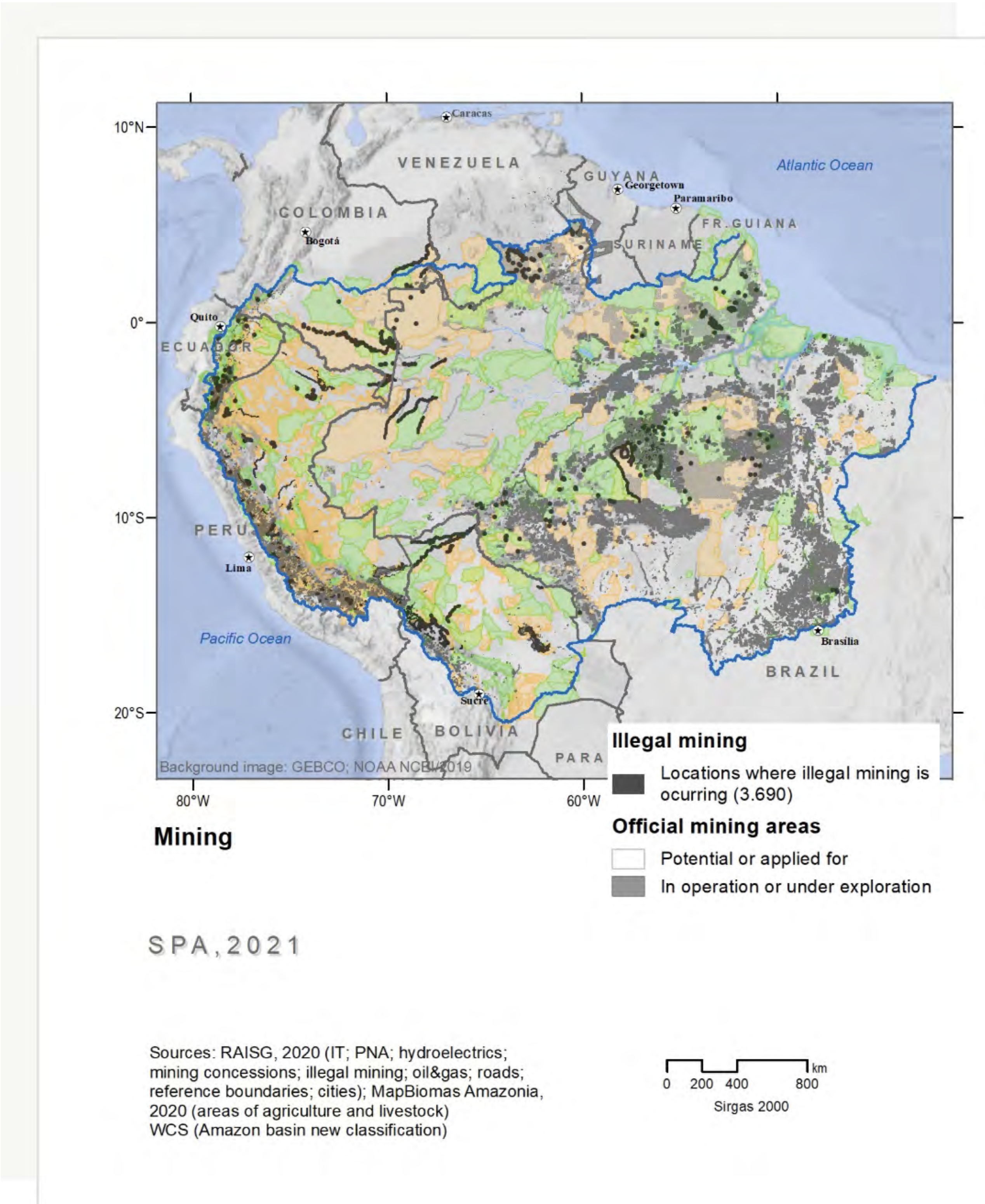


Figure 31.3 Mining activities. Source: RAISG 2020

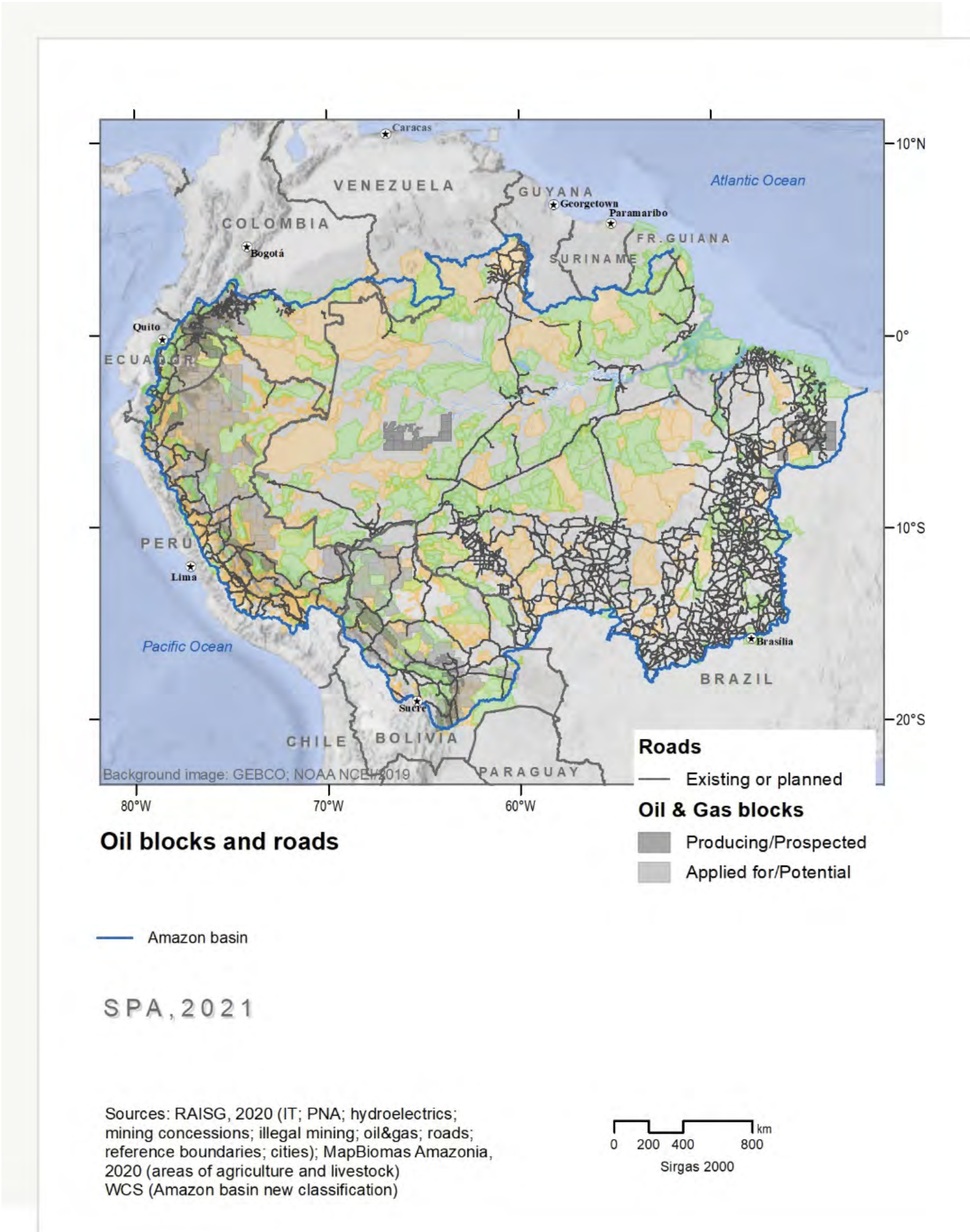


Figure 31.3 Oil blocks and roads. Source: RAISG 2020

ples and communities, although they are still limited by institutional and legal frameworks and by the existence of groups with disproportionate influence over the governance of their territories, including those that engage in illegal activities and challenge the authority and legitimacy of those peoples that aspire to consolidate their autonomy (see Almeida 2019 for Brazilian agromineral export strategies). These initiatives are the outcome of complex and intertwined historical processes. On the one hand, Indigenous and other traditional Amazonian peoples have established, throughout history and mainly at the local level, ambivalent relations with colonialist, integrationist, and assimilationist practices in order to maximize, albeit in a subaltern stance, their participation in territorial, development, and conservation policies of successive governments, and thus to consciously and instrumentally use these policies to defend their territories. At a broader level, through the emergence of the Indigenous movement, which Bengoa (2006) calls "the indigenous emergency", and the political rights-based activism of Indigenous organizations, one can witness the rise of autonomy as a new paradigm in the struggle for decolonization and the appropriation of the concept of self-determination (that some see as a new paradigm) to resist integrationist and assimilationist policies typical of colonial configurations. The construction of this new paradigm takes place in the context of the promotion and protection of human rights and, in some cases, as in Bolivia[p] and Ecuador, is configured in the perspective of building post-national or plurinational societies.

During the 20th century, politically under-represented groups, mainly from but not limited to the Amazon (such as Afro-descendant communities and Indigenous peoples, as well as other groups that also make up local traditional communities; see Chapters 10 and 13), were strictly controlled by the authoritarian state apparatus, motivated, among other reasons, by the racially- and ethnically-homogenizing idea of the nation-state. In Brazil, so-called "fraternal protection" provided by the Indian Protection Service (a Republican agency under the Ministry of Agriculture for the most part of its existence) was based on the idea that the Indigenous condition was a passing one, and that the role of the State was to guide this evolution in a supposedly smooth way. This did not hamper the unabashed use of open, crude, and bare genocidal violence, as documented recently by the Truth Commission (Brasil CNV 2014; Barretto 2018).

Therefore, extreme political centralization, mainly during dictatorial periods, and the invocation of the cultural, linguistic, and territorial unity of the Nation State in Amazonian countries were consolidated through dominant political, economic, and ideological elements, and supported by generic aspects that did not consider the differences between the many groups that constituted their respective societies, exercising power through the establishment of arbitrary criteria of classification, territorial limits, and the perpetuation of elites' genealogies. The concentration of power of Amazonian elites through appropriation of the State apparatus, combined with the crystallization of the idea of political heredity, resulted in the invisibility and exclusion of political and cultural "minorities", which were relegated to the margins of the political, economic, and social spectrum. In this context, such subordinated groups started, in the last third of the 20th century, an intense process of collective mobilization based on ethnical and territorial criteria of belonging, to demand their collective rights to land and the recognition of their specific identities (see Chapter 10 for the notion of "de-colonization" through these processes and the emergence of grassroots movements). These collective demands are directly linked to these peoples' and communities' way of life, their appropriation and use of specific natural resources, and their ontological ties to land (Conklin and Graham 2009, Little 2004).

[p] In the case of Bolivia, these changes have had some local negative externalities, since they also led to increases in deforestation, as people have moved from one area to another and have started using their own traditional practices in ecosystems that are actually managed differently by local people - like the case of multicultural people (i.e, mainly people from the highlands) that were given land in the Amazon region (state of Pando).

These ethnic movements came from cultural self-awareness and an identity consciousness that arose within these groups' lived experiences (Bourdieu 1989; Hobsbawm 1991). In Brazil for instance, after the 1988 Constitution, social movements were mainly motivated by demands around territorial and identity rights, and by environmental protection, especially in the Amazon, allowing for the institutionalization of a state policy that recognized traditional peoples and communities, thus expanding the expectations of other groups.[q] These groups then organized themselves into social movements to defend their own territories and identities, although in practice, the state continued to ignore the demands of these groups.[r]

Formal legal recognition and political-administrative protection of Afro-descendant territorial rights could be the key to settling many conflicts involving territorial disputes, natural resources, and the very existence of these groups, but in practice is ineffective given the influence of neoliberal policies[s] adopted by the different nation-states on local peoples' and communities' rights.[t] On the one side, some countries have responded to the demands of peoples and communities in the Amazon with the recognition of their cultural and/or political identities; whereas, on the other side, to meet the demands of capital, they have hindered the implementation of their rights.[u] It is in this sense that we say some Amazonian countries have operated in the orbit of neoliberalism (Hale 2005; Gaioso 2014). In the case of Brazil, one can say it has assumed the status of an "acknowedging state", treating identity recognition as a bureaucratic process, which makes it possible to guarantee the rights to identity, although not to full collective existence, because this recognition finds limits in the interests of policies fostered by the state, thus promoting what Fraser (2002) calls recognition without redistribution (of land, for instance).

In general, the establishment of neoliberal policies in Amazonian countries constitutes a real threat to the life of the region's existing peoples and communities. When implemented in traditionally occupied territories, they put the full diversity of these peoples and their important biocultural connections that support the conservation of the regions' socio-biodiversity at risk (Chapters 10 and 12). These human collectives express themselves through specific territorialities (Almeida 2006) fashioned through particular historical processes and social situations. The construction of these specific territorialities leads to a process of otherness experienced by certain local peoples and communities in relation to (neo)colonial society, which explains why such groups reproduce their social memory once they affirm their autonomy (Almeida 2008). In other words, the historical process of constitution of these specific territorialities helps to understand how it was possible to establish, maintain, and reproduce social and ecological relationships and bonds, and how these territorialities and their corresponding collective identities distinguish themselves from each other (Cunha and Almeida 2000).

---

[q] In the case of Brazil, these groups included *ribeirinhos, piaçabeiros, quebradeiras de coco babaçu,* Brazil nut harvesters, traditional fishers, *vazanteiros, geraizeiros, fundos de pasto, fechos de pasto, faxinais, peconheiros, extrativistas, caiçaras* - among others, whose designations referred to either an ecosystem, productive habitat, or a kind of agroextractivist activity (i.e, to a territorially grounded existence).

[r] For evidence of the important role that social movements played in achieving special sociocultural and territorial rights recognized across the Amazon, see Moreira et al 2019, and also Sobreiro 2015a,b.

[s] As far as neoliberal policies in Latin American countries are concerned and their connection with the regime of accumulation by dispossession, as a new round of commons enclosure, it is worth citing Harvey: "The *corporatization and privatization of hitherto public assets* (such as universities), to say nothing of the *wave of privatization* (of water and public utilities of all kinds) that has swept the world, indicate a new wave of 'enclosing the commons'. As in the past, the power of the state is frequently used to force such processes through, even against popular will. The *rolling back of regulatory frameworks designed to protect labour and the environment from degradation* has entailed the loss of rights. The *reversion of common property rights* won through years of hard class struggle (the right to a state pension, to welfare, to national health care) to the private domain has been one of the most egregious of all policies of dispossession pursued in the name of neo-liberal orthodoxy" (Harvey 2003: 148 - italics added).

[t] It is worth emphasizing the influence of neoliberal policies on the territorial rights of indigenous peoples and traditional communities, mainly the weakening of the capacity of governments, which prevents the implementation of the legislation on land demarcation or the arrest of its transgressors, and the return and sharpening of a developmental model reminiscent of the dictatorship in its "neo-extractivist" version (Svampa 2019).

[u] Besides, as one reviewer observed, even in those countries where Indigenous peoples' rights are acknowledged, such as in Colombia, their effectiveness in the right holders' lives has been historically hampered.

Last but not least, it is worth highlighting that the movements in defense of traditional territories and the Amazon have been enriched by women's movements from Indigenous, traditional, riverain and Afro-descendant peoples and communities. Because of the different roles and division of labor between women and men in such diverse cultural systems, women's relations with their territories and biodiversity are specific. They generally occupy a peculiar place in knowledge regimes that are ancestrally (re)generated from mothers to daughters. Moreover, the threats and risks to the livelihoods of these peoples and communities affect women in different (often more brutal and subtle) ways. Since women have been made invisible in all the above-mentioned situations, and given the specificity of their rights, they have burst into the national and international arenas to assert their identities as Indigenous peoples (or traditional communities, or Afro-descendants) and their distinctiveness as women to gain strong political influence (Frank 2018; Real and Ruiz 2019).[v]

In the next section, we present a very small fraction of the immense variety of inspiring pathways that are continuously being built (i.e. as you read this text) on the ground, connecting multiple scales and levels of sociocultural integration, from grassroots organizations to international arenas, that point to a more forest- and justice-friendly Amazon.[w] The aim is to identify common strategies and lessons learned (for good or bad) that can help us pave the way to a life-nurturing scenario that can dismantle today's hegemonic necropolitical configuration.

31.2. Inspiring solutions pathways

The territorial management of protected areas, Indigenous lands, and local and traditional communities' territories in the Amazon is made up of a fertile and rich collection of experiences and practices that are simultaneously participatory and integrative, some of which we mention in this section. As we will show, various actors, institutions, and organizations from governments, civil society, academia, and social movements (of local, regional, and national scopes), are brought together in a horizontal way, to interconnect different scales of action, competencies, attributions, and knowledge regimes with the aim of guaranteeing, simultaneously, improvements in the quality of life of Amazonian peoples and communities, the vitality of their livelihoods and territories, and the conservation of their associated ecological and cultural values. All these objectives are both relevant to public interest and, we dare say, integral to creating alternative civilizational pathways.[x] Some of these experiences, initiatives, and practices already occur at a local scale on a daily and relatively invisible basis, since for many of these peoples and communities we are talking about their livelihoods. Nevertheless, as some of the instances described show, there were ***rare*** occasions when idiosyncratic and singular political circumstances favored governments to welcome such experiences and their emancipatory potentials, thus benefiting those groups in resisting threats and pressures.[y]

Territorial management reaches its objectives when it reflects the peoples' and communities' standards and interests, by empowering and promoting their access and participation in the

[v] For a tropical non-Amazonian example of the centrality of women in such issues, see Branco's 2019 dissertation on women's protagonism in multi-ethnic Indigenous movements of territorial recovery in southern Costa Rica.

[w] We decided to let the various authors be rather free in presenting the experiences with which each of them are engaged, not imposing any predefined template, with the hope of capturing the mood and filigrees that are also constitutive parts of these engagements. This explains why some of the experiences look like case studies, while others tend to highlight the lessons learned.

[x] To better understand the idea of alternative civilizational pathways, one should get acquainted with the works of Indigenous intellectuals, such as Ailton Krenak (2019, 2020) in Brazil and Silvia Rivera Cusicanqui (2013, 2014, 2015) in Bolivia.

[y] Instances when/where emerging and/or consolidated social movements have leveraged and gained official support for their initiatives can be found in different countries. Examples: Brazil, the rise of the Extractivist Reserve as a legally-recognized protected area, and acknowledgement of fishing agreements; Peru, the formal demand for *planes de vida* (life plans) as a formal requirement for titling *comunidades nativas* (native communities); Colombia, the establishment of horizontal and participatory governance schemes focusing on micro regions, such as the Apapóris.

definition of procedures, instruments, and resources. Such experiences have taught us that, from the perspective of building fair forestry management in a sustainable Amazon encompassing both people and environment, what we call public territorial management must necessarily be linked to the ideas and practices of strengthening citizenship, social participation, expansion of political action by civil society and social movements, symmetrical connection between knowledge regimes, and democratic engagement and decision making.[z] This includes local, heritage, and vernacular on the one hand, and on the other, scientific (Athayde *et al.* 2017). In the Amazon in particular, this configuration is effective for the territorial management processes taken on by Indigenous and local communities in protected areas of different denominations and management categories (Chapter 10).

In this way, we understand that territorial management encapsulates, equally, "the political dimension of territorial control and the environmental dimension of actions directed at the sustainability of natural resources" (Little 2006), both anchored in interdisciplinary scientific endeavor (Little 2010). Therefore, territories cannot be considered by their "natural factors" or by their "human talent" (Abramovay 2003), but instead as life worlds in which mental and behavioral configurations are generated and shared, not defined by the supposed objectivity of the factors at disposal, but by the way they are collectively organized (Beduschi and Abramovay 2003).

The different Amazonian initiatives considered here reinforce the concept that, regardless of international milestones and national policies, the effective dimension of collective well-being and sustainability is established in (and generates) "places". Given the threats that protected areas face, expressed through the (neo)colonial pattern of neo-extractive development highly demanding of land and natural resources common to all Amazonian countries, the autonomous management of these social territories can be understood as a sketch towards the pluriverse: a "world where many worlds fit" (Escobar 2020).[aa]

Some of the central elements found in most of these initiatives are the valorization of local natural, technical, and human resources oriented towards autonomy and self-support; the recognition of existing cultural traditions and knowledge regimes; the care and respect for the environment; and an approach to collective well-being according to the perspectives of the peoples and communities involved. This is why such experiences reinforce the need to push forward collective territorial management based on guaranteeing rights, since territorial security is the foundation and condition for its autonomous, integrated, and participatory management.

In order to strengthen the contribution of local peoples and communities to conservation, we agree with what some consider an outmoded formulation from Stavenhagen (1985), according to whom public policies must act as "catalyzing elements for sociocultural processes that assure these groups' autonomy — their rights to control their own lands, their own resources, their own institutions, their own social and cultural organization, and their own path to negotiation with the state, and, as such, defining the type of relationships they want to have with it".

31.2.1. Life Plans and Territorial and Environmental Management Plans

Ensuring the governance of Indigenous lands by Indigenous communities themselves has been

[z] We wish to make clear that, as far as political matters are concerned, we are talking about both leveraging these initiatives in a democratic way, and improving the practice of democracy.

[aa] '[R]ealities are plural and always in the making, and [...] this has profound political consequences. The very concept of world, as in the World Social Forum slogan "Another world is possible," has become more radically pluralized, despite by social movements mobilizing against large-scale extractive operations in defense of their territories as veritable worlds where life is lived according to principles that differ significantly from those of the global juggernaut unleashed on them. If worlds are multiple, then the possible must also be multiple. [...] another world is possible because another real and another possible are possible" (Escobar 2020).

shown, over the years and in different regions of the Amazon, to be one of the most effective ways to guarantee ecosystems, quality of life, and respect for cultural and territorial rights. The work done collectively among Indigenous communities, their organizations, and civil society organizations has given rise to culturally-based governance tools that have safeguarded Indigenous territories. Two of them have received special attention: Life Plans and Territorial and Environmental Management Plans.

Life Plans and Territorial and Environmental Management Plans are ways of guiding the use of Indigenous territories and their natural resources, with the objective of meeting the current cultural, social, and economic needs of the peoples that currently live there and also conserving the environment for future generations. A set of objectives, actions, and activities are considered, discussed, organized, and agreed to be carried out in the short, medium, and long term. A set of goals and actions are elaborated from collective agreements on how to manage territories based on cultural values and social organizations built through community meetings, workshops, and discussions, based on socioeconomic, ecological, and cultural surveys. They allow Indigenous communities to identify the opportunities and threats present in the lands they inhabit and make a plan to order their own ways of use and occupation, guaranteeing their well-being and quality of life now and in the future.

They are not only internal agreements between communities, but, at least in the case of Colombia, intercultural agreements with the State through consultation tables, intergovernmental tables (between the Indigenous government and the departmental governments) among other national scales. Officially acknowledging the relevance of such instruments, Colombia's Interior Ministry (*Ministerio del Interior* website) provides access to more than 40 life plans (*plan de vida*, *plan integral de vida*, *plan nacional de vida*, *plan de justicia y vida*) of various Indigenous peoples, communities, *resguardos*, *cabildos*, and *municipios* (see https://siic.mininterior.gov.co/content/planes-de-vida).[bb]

The same partially holds true for the territorial and environmental management plans of Indigenous peoples in Brazil, a recent example being the Yanomami and Ye'kwana plan. Although not an officially-sanctioned intercultural agreement, in July 2019 leaders from the Yanomami Indigenous Land visited 13 federal agencies in Brasília and Manaus to express that they were ready for any conversation concerning their land (the largest Indigenous Land in Brazil). They took with them their Territorial and Environmental Management Plan, constructed with the participation of at least 100 people and considered by them to be the most important collective agreement for the future of the 26,000 people who live on their land.[cc]

Thus, these plans connect knowledge and experiences that update the spiritual, cultural, and material traditions and perpetuity of these peoples, functioning as a political and planning instrument that configures the particular vision that an Indigenous society has of its own history and collective identity. It should not be forgotten that in some Amazonian countries life plans originate from the planning tools of the State itself, adapted — not always successfully — to the organizational forms and conceptions of the territories of Indigenous peoples. In other countries, State apparatus appropriated these tools, and still in others Indigenous peoples learned with each other horizontally how to manage such a tool.

A life plan is composed of and systematizes the set of knowledge, spiritual practices, and rules transmitted by traditional leaders, (re)generated from generation to generation. It leads to a process of collective reflection on the past, present, and

[bb] An interesting instance in Colombia is the Misak people's "life, survival and growth plan" (*plan de vida, de pervivencia y crecimiento*), which they have been developing and carrying out, and expresses their own broad view of a self-determined development (plan_de_vida_y_pervivencia_misak.pdf (mininterior.gov.co)). The ways the Misak Taitas and common people evaluate their plan can be seen and heard in this short 2015 documentary https://www.youtube.com/watch?v=z0FOOkqW_RI&t=49s.

[cc] The ways the Yanomami and Ye'kwana see their plan can be seen and heard in this short 2019 video #VivaYanomami https://www.youtube.com/watch?v=7-u87UhhQDQ&t=4s.

future of Indigenous peoples and, as mentioned above, their ability to respond to the challenges posed by continuous interaction with segments of non-Indigenous societies.

In recent years, countless communities and Indigenous peoples across the Amazon have developed and implemented their life plans and management plans, making strategies for monitoring and territorial surveillance, management of natural resources, recovery of degraded areas, new economic activities (including socio-biodiversity products for the regional market), and the upbringing and education of new generations for the care and protection of their territories.

These plans are effective responses to the diverse pressures and threats Indigenous peoples increasingly face across the Amazon Basin. One can read them as a renewed territorial management paradigm, but they are also attempts at (re)generating ancestral conceptions of territories and their care, aligned with state policies and/or the work of NGOs as a means of not losing connection with their territories. It is worth acknowledging the various challenges faced in the design, construction, and implementation of these plans, not the least of which is their incorporation into other national and subnational government plans. Notwithstanding these challenges, it is necessary to work side by side with Amazonian peoples to further protect ecosystems, guarantee a dignified life, fully realize the right to self-governance according to cultural values, safeguard resources for current and future generations, and search for autonomous revenue-generating alternatives as these pans are implemented and sustained.

31.2.2. Indigenous territorial management in the greater Madidi landscape

The Madidi–Tambopata landscape is in northwestern Bolivia and neighboring Peru, stretching from the High Andes to the tropical lowlands. It covers 14 million hectares, encompassing 8 protected areas (5 national and 3 subnational), 8 Indigenous lands, and the communities of 10 Indigenous peoples. Connectivity and overlap between protected areas and Indigenous lands across the Amazon is critical to maintaining intact forests for wide-ranging species (e.g., jaguar), as well as for maintaining globally important ecosystem services (e.g., climate mitigation, freshwater provision). The Wildlife Conservation Society (WCS) has been working in the Greater Madidi–Tambopata landscape in Bolivia for two decades to support efforts by Indigenous peoples to secure legal recognition of their ancestral territories and increase their capacity to manage their lands and waters.

This is partly achieved by developing Indigenous Life Plans (or territorial management plans) for 1.8 million hectares of titled and claimed Indigenous territory. These plans establish recommendations to protect their lands, using and managing natural resources in line with environmental, social, and economic sustainability criteria. Such plans also contribute to the preservation of Indigenous cultural identity and revalorization of ancestral knowledge, highlighting the relevant contributions of Indigenous women in strengthening cultural identity and revaluing ancestral knowledge. They identify areas where conservation and development objectives can be achieved, as well as connectivity corridors that link protected areas and Indigenous lands, to enhance the conservation of intact forest and healthy wildlife populations.

Improving management capacity has resulted in increased awareness among Indigenous organizations and communities of the environmental, economic, and socio-cultural benefits of territorial management and have helped secure local land rights. Local Indigenous peoples value the ordering and titling of their territories and benefit from increased security in access to and use of natural resources and the development of productive enterprises. The lives of Amazonian Indigenous peoples depend on maintaining a harmonious relationship with nature for their spiritual, social, cultural, and economic development. This model has been developed from the perspective and cultural identity of Indigenous peoples, which also strengthens their commitment to biodiversity conservation.

Actions to conserve nature and natural resources are closely related to the rights of people to secure their livelihoods, enjoy healthy and productive environments, and live with dignity. The pursuit of conservation goals can positively contribute to the realization of many fundamental human rights. Likewise, secure rights—for example, land tenure, and participation in decision-making—can enable more effective environmental stewardship.

A rights-based approach guides the alliance between the WCS and the Lecos, Tacana, T'simane Mosetene, and Pukina peoples. This approach recognizes that Indigenous territorial rights are inalienable; the existence of Indigenous peoples depends upon them, as does their social, economic, and cultural development. The right to self-determination is linked to the historical imperative to repair the effects of colonization. In this landscape, Indigenous territorial management is not a means to achieve conservation, but a partnership based on negotiation, consensus, and coordination of strategies and actions that can be broadly described in ten steps:

1. Consolidation of land rights
2. Strengthening and leadership of the organization
3. Indigenous Territorial Management Plans
4. Zoning processes
5. Rules and self-regulation of natural resources
6. Specific management of natural resources
7. Territorial control and surveillance
8. Development of administrative capacities
9. Sustainable financing mechanisms
10. Capacity building for monitoring and research

In the next decade, partnerships to develop sustainable finance for Indigenous territorial management based on respect for rights, transparent financial management, and effectiveness of implementation for nature and people will be critical. Developing internal cohesion for territorial management is required to face external pressures and the direct and indirect impacts of extractive and infrastructure development projects. However, in a context of increased conflict between Indigenous visions and regional, national, and subnational policies, the next decade also requires political will to uphold Indigenous territorial rights. In response to increasing illicit extractive activities, it is necessary to identify legal alternatives, in both national and international contexts, to safeguard the rights of Indigenous peoples and increase the capacity of Indigenous organizations to safeguard their collective rights. Throughout the Amazon, it will be vital to promote the participation of Indigenous people in the environmental justice processes required to address these threats.

31.2.3. Assets-based quality of life planning and integrated territorial management for the Andes-Amazon region

The Field Museum's Keller Science Action Center in Chicago, Illinois (United States), has developed a range of strategies to align conservation priorities with local peoples' aspirations in the Andes-Amazon region. Inspired by assets-based community development (Kretzmann and Mcknight 1996; Mathie and Cunningham 2003), which focuses on community strengths and capacities rather than deficiencies, the Field Museum developed an approach to community engagement in conservation that prioritizes the empowerment of local people. The Field Museum team has field-tested this approach in both short-term and long-term processes. One short-term method is a rapid social inventory, conducted as part of an integrated biological and social inventory (see Collaborative Knowledge Production and Coalition Building for Conservation Action through Rapid Biological and Social Inventories in Chapter 33). Social inventories conducted by the Museum and its partners identify the many ways local peoples rely on natural resources for their livelihoods and protect and enhance landscapes through their lifeways. The inventories also document patterns of social and political organization that can be used to support environmental protection and highlight the spiritual and cultural significance of landscapes for Indigenous and other rural residents, drawing attention to how local peoples' attachments to places can be channeled toward support for conservation. For instance, results from social inventtories were used by local communities and decision-makers to develop co-management systems for the Ampiyacu–Apayacu Regional Conservation Area and Yaguas National Park in Loreto Department, Peru.

Other asset-based strategies sustain long-term engagement with local people. The Field Museum team first developed an asset mapping process called the *Mapeo de Usos y Fortalezas*, or MUF, as a way of translating the initial social inventory moment into a longer process of reflection, dialogue, and relationship-building. The first MUF was developed in the early 2000s in collaboration with the Peruvian Parks Service (now SERNANP), the NGO CIMA, and various local peoples' organizations and implemented with communities adjacent to Cordillera Azul National Park in Peru (del Campo and Wali 2007). Building on the MUF, the Field Museum team began developing "Quality of Life (QoL) Plans" with Indigenous and campesino communities in other parts of Peru to expand and deepen engagement with local people and ensure more sustainable, just, and locally-appropriate conservation strategies. QoL Plans now exist for communities in the buffer zones of Cordillera Azul National Park (2009–2011), Ampiyacu–Apayacu Regional Conservation Area (2011–2015), Sierra del Divisor National Park (2011-2015), Bosque de Protección San Matías-San Carlos (2016–2018), and Machiguenga Communal Reserve (2017–2019). In total, the Field Museum team has supported the development of 52 QoL Plans in Peru.

The Field Museum's Quality of Life planning methodology builds on other Indigenous Life Plan processes and is unique in its focus on aligning environmental conservation and quality of life. It uses a combination of participatory methods to distill community histories, natural resource use, ecological calendars, community organizations, and relationships with outsiders, and draws upon them to inform priority-setting for community development and conservation. The planning process also provides an opportunity for communal reflection and evaluation of different components (social, environmental, cultural, economic, political) of well-being. Finally, QoL Planning is designed to generate a set of community-driven actions that a) integrate multiple components of well-being, b) build on community assets, and c) are feasible and implementable without excessive dependence on outsiders. The community then prioritizes these actions and develops an implementation plan. A guide to QoL Plan methodology is available at https://www.conservationforwellbeing.fieldmuseum.org.

The Field Museum team has found that MUF and QoL planning help build local support for protected areas and local communities' territories by identifying points of alignment between community well-being and conservation, and by leading communities to shift toward more conservation-friendly priorities (Wali *et al*. 2017). For example, in some communities, QoL planning has led to a shift from fish farming to natural fisheries management. In one community, Yamino, reflections during QoL planning led a group of individuals to lobby the rest of the community to stop timber extraction and to create a reserve area where they collect seeds and mahogany bark for making handicrafts. The QoL planning process has also facilitated the development of working relationships between communities and protected area personnel. For example, communities adjacent to the Ampiyacu–Apayacu Regional Conservation Area expanded a voluntary community monitoring regimen after participating in QoL planning.

The Field Museum team has learned various lessons from Quality of Life planning processes in Peru. First, connecting communities with allies that can help them enact their prioritized actions is essential to successful implementation. Second, early engagement with local authorities is key to ensuring that QoL plans will be recognized and community priorities taken seriously. In some early QoL planning processes the team did not bring in municipal governments until the end of the process, which diminished the authorities' investment in the process. In contrast, in Poyentimari early local government involvement led the Municipality of Echarati to formally recognize Life Plans as a legitimate community planning instrument. Third, the Field Museum team has found that simply developing QoL plans is insufficient; their development has to be part of a broader strategy for integrated territorial management that ensures local peoples' aspirations are centered in public policy. Successful integration of territorial management only occurs when local governments, protected areas, and local communities align their visions and priorities. From 2016–2019, the Field Museum worked with SERNANP, the Peruvian national planning agency (CEPLAN), the Ministry of Culture, the National Forest Conservation Program (PNCB), the Ministry of Development and Social Inclusion (MIDIS), and local governments to ensure alignment among local development plans, protected area management plans, and QoL Plans in the Urubamba and Pachitea watersheds of central-southern Peru. This effort contributed to the formal recognition of QoL plans as planning instruments and informed the development of guidelines published by the Peruvian Park Service.[dd] An alliance of organizations, including the Field Museum, is working to apply the lessons learned to Putumayo Province (Peru), where there is a unique opportunity to sustain and enhance connectivity among protected areas, Indigenous territories, and other conservation-friendly territorial regimes. This led the Museum team to build partnerships between communities and government agencies to promote alignment between QoL plans, protected area management plans, and local development plans.

31.2.4. Macro-territory of the People of Yurupari (Departments of Vaupés and Amazonas, Colombia): Traditional knowledge as a basis for territorial management to consolidate a conservation model

This section is based on 15 years of endogenous research (i.e., conducted by the Indigenous peoples themselves) by the Barasano, Makuna, Eduria, Tatuyo, Letuama, Tanimuka, Yukuna, and Matapi Indigenous peoples of the northwestern Amazon, a process that has been supported by the Gaia Amazonas Foundation (2020). Different studies demonstrate that Indigenous peoples are essential guardians of the environment. Deforestation rates are very low in their territories (FAO 2012). This is largely due to the way Indigenous peoples live and their vision of the human–nature relationship. However, government- and civil society-led socio-economic development programs have a different vision and end up imposing themselves and denying the Indigenous relationship of coexistence, reciprocity, and regeneration.

In the face of the climate crisis, one of the greatest challenges is to seek answers through the construction of intercultural processes that articulate the best of these two visions. In this search, essential issues such as life plans, environmental management plans, protocols, and agreements, all based on the development of Indigenous peoples' rights, have been addressed. Nevertheless, a step further is necessary to understand and take seriously Indigenous world views, as well as those of many other cultures different from our own.

For Indigenous peoples, nature is conceived of as a great system of life in which humans are but one part; it is a community of subjects, interrelated and interdependent in various dimensions of physical and spiritual reality. Sacred sites, spirits who own nature, and communication with these spirits through shamanism are fundamental to human coexistence as part of nature. It is from this paradigm that Indigenous peoples structure their social, territorial, and environmental governance. In Western society, the paradigm is different; nature is at the service of humans and is a collection of objects that provide resources. In principle, nothing is sacred and only governments or local owners need grant permission.

In the midst of this dichotomy are significant changes that bring Western society closer to the Indigenous paradigm. One is the recognition of the rights of nature, for example in the constitutions of Ecuador and Bolivia, legislation in Colombia that recognizes the Amazon as a subject of rights (CSJ 2018),[ee] and related experiences in New Zealand, India, and Australia, among others.

[dd] See guidelines published by the Peruvian Park Service (SERNANP) in Document 34: http://sis.sernanp.gob.pe/biblioteca/?publicacion=1914.

[ee] See Sentencia 4360 de 2018, https://cortesuprema.gov.co/corte/index.php/2018/04/05/corte-suprema-ordena-proteccion-inmediata-de-la-amazonia-colombiana.

On the path towards establishing an increasingly close relationship between these worlds, Gaia Amazonas Foundation has accompanied Indigenous peoples in the development of pedagogical methodologies that allow the translation of their life worlds to Western contexts, generating new dynamics of intercultural relations and joint management. Indigenous peoples have positioned and legitimized traditional systems of regulation and knowledge through the development of local, endogenous research programs. These programs are based on knowledge elders share with research teams comprised of Indigenous youth, guaranteeing the transmission of knowledge to new generations and documenting it through recording, writing, translation, and systematization carried out by the Indigenous people themselves and complemented by traditional rituals.

By decoding and recoding this knowledge and making it available for intercultural territorial management, these systems gain legitimacy and are fully recognized as instruments for governing their territories. The process of translating traditional knowledge into intercultural territorial management instruments constitutes a regenerated paradigm that strengthens governance within Indigenous territories and management strategies on a regional scale.

In Colombia, Yaigojé Apaporis National Park and Indigenous territory, located between the departments of Vaupés and Amazonas on the lower basin of the Apaporis River,[ff] has been recognized as a successful example of territorial management based on Indigenous knowledge. This process began in 2009, when a mining company wanted access to sacred natural sites within the Indigenous territory. Its Tanimuka, Makuna, and Letuama inhabitants, seeing that they could not prevent it, decided to form an alliance with National Natural Parks (PNN) to guarantee the integrity of their territory and culture. Although the communities have collective ownership (*resguardos*) of surface land, the State retains ownership of underground resources, which exposes Indigenous territories to extractive activities such as mining. PNN, whose competencies include protecting the subsoil, was interested in protecting the biodiversity of this region for more than two decades. In negotiations, the Indigenous people agreed to share environmental management with PNN on the condition that it was based on traditional knowledge, while PNN accepted on the condition that the Indigenous people would elaborate a verifiable management plan based on their knowledge, complemented in a respectful manner by scientific knowledge, within a period of five years. On the instruction of the elders and traditional authorities, this management plan was constructed with the communities because it is not possible to maintain harmony with the environment without the participation of everyone.

In this particular case, endogenous research resulted in the development of the Yaigojé Apaporis National Park Special Management Regime (REM, its Spanish acronym),[gg] recognized by environmental authorities as the only management instrument for this protected area. Moreover, in the cultural-territorial nucleus known as the Jaguars of Yuruparí (because of certain rituals), there are other instruments, for example the Special Safeguarding Plan (PES, its Spanish acronym) of the Pirá Paraná River and the Environmental Territorial Ordering System (SOTA, its Spanish acronym) of the Mirití River territory.

These processes, when understood from the integral and complementary nature of these territories and recognizing that the management of each one is closely articulated with the neighboring territory, constitute a large territorial complex governed by the same principles. Management of the Jaguars of Yuruparí based on the Indigenous paradigm has proven an effective conservation model for the protection of the forest; this territory of 8

[ff] See https://www.gaiaamazonas.org/noticias/2020-10-27_el-territorio-indigena-yaigoje-apaporis-cumple-once-anos-desde-su-declaracion-como-parque-nacional-natural.

[gg] See https://www.amazoniasocioambiental.org/es/radar/el-pacto-de-los-guardianes-del-apaporis.

million hectares maintains 98% forest cover (IDEAM 2019).

This experience is based on proven and replicated methodologies, which have made it possible to elevate ancestral knowledge of environmental management in the development of innovative intercultural strategies for conservation and environmental connectivity in the Amazon. It represents a fundamental advance in the participation of Indigenous peoples in proposals for the future of the planet and new schemes of sustainable development based on diversity. No single culture has the answer to all the challenges and questions that we face with the climate crisis.

31.2.5. Autonomous community consent protocols by Indigenous, Afro-descendant, and local peoples

The Amazon has been an arena of innovative initiatives that point to greater political leadership and the exercise of autonomy by Indigenous peoples and local communities. In a movement where a diversity of voices are calling for the realization of their rights of participation and autonomy, these peoples have developed and proposed to national governments autonomous protocols for prior consultation and consent, in which they explain the time, manner, places, and people that must be called upon to participate in free, prior, and informed consultation (FPIC) processes, regarding public (including conservation) policies, development programs and projects, private undertakings, legislation and other measures that affect them and their territories.

Initiatives for the development of autonomous consultation protocols point toward the effectiveness of the right to consultation in the region, and they propose a clear and objective path to guarantee the fundamental right to participation of Indigenous peoples, Afro-descendants, and other local communities in State decision-making processes.

The right to prior consultation arose from the need to recognize the diverse forms of organizational and political representations of Indigenous and local peoples and to establish dialogues in good faith between them and national states on all matters of interest. This was established by ILO Convention 169, the United Nations Declaration on the Rights of Indigenous Peoples, the American Declaration on the Rights of Indigenous Peoples, and numerous human rights treaties that recognize FPIC as a basic principle of the contemporary relationship between States and peoples with different cultures (Garzón *et al.* 2016).

Article 6 of ILO Convention 169 requires that consultation processes be adapted to the particular procedures and circumstances of the peoples, and that they are carried out through their representative institutions in good faith and according to their customs, languages, and traditions. In other words, the procedures must adapt to the realities of the peoples and not the other way round.

The right to prior consultation constitutes a mechanism for social participation in the decision-making process of the State and for the realization of democracy; it is a mechanism that can guarantee the effective participation of Indigenous, Afro-descendant, and local peoples and communities in the context of a plural society that recognizes and values cultural differences. In general terms, the right to prior consultation imposes an obligation on States to appropriately and respectfully ask Indigenous and tribal peoples their opinion on decisions that affect their lives.

The processes for developing autonomous consultation and consent protocols in the Amazon have also presented an opportunity for local communities to prepare themselves to exercise the right to be consulted, to freely and autonomously decide who can speak for the people or community involved, and maintain a dialogue with State representatives such that everyone feels represented and committed to what is being discussed. This reflects that it may take significant time to build internal consensus, and ensures that agreements are fulfilled and have legitimacy (Yamada *et al.* 2019).

In a context in which different Indigenous peoples elaborate and implement life plans and territorial and environmental management plans across the

Amazon, consultation protocols emerge as a complementary tool to organize dialogues between Indigenous peoples and the State, when public policies deal directly with their rights and territories, but also when the possibility of actions that affect their ways of life, territories, and natural resources, arise. Autonomous consultation and consent protocols tend to reinforce internal governance agreements for Indigenous territories and ongoing territorial management proposals.

Most life plans and management plans that have already been drawn up bring together a set of community agreements and priorities established in terms of territorial surveillance, productive activities, environmental recovery, and natural resource management, thus recording and informing others, including the State, of internal agreements to guarantee quality of life and environmental sustainability. Ultimately, they represent commitment to a set of actions and intentions for the coming years, subject to revisions and updates. Autonomous consultation protocols address the possibility that government proposals (such as infrastructure works and neo-extractivist industries, within or around local communities and/or territories) can potentially impact IPLCs' rights and, therefore, the territorial management proposals.

Consultation protocols tend to raise consensus on the political representation of peoples and the way they make decisions on behalf of a specific people and community, allowing them to strengthen their internal governance models. They also make it possible to discuss, in light of their own life plans and management plans, relevant socio-environmental impacts of each project and, therefore, its feasibility, as well as address issues related to the effectiveness and relevance of mitigation and compensation measures.

These two instruments, life plans/management plans and autonomous consultation protocols, tend to complement each other in highlighting the role of Indigenous and local peoples in the care of their territories, exercising governance that allows them to seek a quality of life, sustainability, and security for current and future generations in dialogue with governments and state policies.

In the context of building new practices for a more sustainable future for the Amazon, it is imperative to guarantee the participation of Indigenous, Afro-descendant, *quilombola*, and other local peoples in decision-making processes about, and within, the region. Autonomous consultation protocols *should be considered* effective, culturally determined instruments to ensure this *desired* participation. Italics in the previous sentence point to the fact that although there has been a recent surge in the elaboration of such protocols by Amazonian peoples and communities, effective implementation and full compliance still remains an issue; there is no concrete example to date in which the consultation protocols have been effectively implemented. Thus far, they have served to halt undertakings in the Courts for not complying with the procedures established by communities for their consultation (which we consider very important). In Colombia, since 1991 when a new Political Constitution was approved and ILO Convention 169 was ratified, Indigenous and tribal peoples have been judicially demanding the application of the right of prior consultation regarding legislative measures that directly affect them.[hh]

The 'Observatory of Community Protocols of Consultation and Prior, Free and Informed Consent: territorial rights, self-determination and jusdiversity'[ii] registers in its database for Brazil 19 protocols of Indigenous peoples, 11 of Afro-descendant *quilombola* communities, and 14 for other traditional peoples and communities, besides those that are joint protocols. It also refers to three in Colombia, one in Bolivia, and one in Venezuela, but these are conservative figures. It should also be mentioned that consultation mechanisms for

[hh] See https://especiais.socioambiental.org/inst/esp/consulta_previa/index06d0.html?q=node/20.

[ii] A network of researchers and representatives of traditional peoples and civil society organizations that monitors threats and violations to the right to consultation and free, prior, and informed consent in Brazil and other countries in Latin America and Africa. See http://observatorio.direitosocioambiental.org.

Indigenous peoples are mediated and regulated by the countries' respective legal frameworks (in some cases the federal constitutions, in others ordinary laws) and/or policies, meaning that the application of ILO Convention 169 is far from uniform across the region. In Colombia, for example, the so-called "prior consultation" is legally established, whereas in Brazil, there are no specific national provisions, be it legislation or procedures for consultations.[jj]

31.2.6. Collective fishing agreements and co-management of piracuru fisheries in Amazonas State, Brazil

A model for co-management of fisheries has historically been built based on dialogue between local (Lima and Batista 2012) and scientific knowledge, and the formalization (recognition by the official environmental agency and authorities at the State level) of local fisheries agreements (Almeida *et al*. 2009) to ensure the conservation of fishing stocks and the commercial activity of inland artisanal fishing in the state of Amazonas, in the northern Brazilian Amazon. Since the late 1990s, fishers from different local communities in floodplain areas, mainly the Middle Solimões, have developed a managed fishing model for *pirarucu* (*Arapaima gigas*) (Campos-Silva & Peres, 2016). Since then, the model has been improved (Castello 2004) and adopted in several other locations (Oviedo and Bursztyn 2017). Commercial pirarucu fishing has vanished since the mid-1980s due to conservation constraints. Since then, there has been a gradual recovery since the first pilot-scale authorization in the Mamirauá Sustainable Development Reserve in 1999, which demonstrates the potential of combined protected area management and targeting of commercially valuable species. In 2019, Ibama (the federal agency of the environment) issued 38 authorizations, which combined allowed 65,600 fish to be harvested. New public policies for the promotion and legal-political support of the model have been developed and adopted, particularly by the state government, since the federal government currently has the role of authorizing fishing, since *pirarucu* is an endangered species. The importance of this social technology (Silva *et al*. 2020) goes beyond its expression in the local economy and its regional value chain. The adoption of managed pirarucu fishing where there are collective agreements, in addition to recovering local stocks and reactivating commercial fishing activity, reinforces the territorial rights of artisanal fishers over aquatic environments for collective use and preserves local knowledge and culture associated with fishing for this iconic species.

Since this is a relatively long-standing experience in the Brazilian Amazon, at the time it appeared, the idea of carrying out a value chain analysis was not even conceivable by the actors (mainly local and grassroots) involved — even less in terms of gender. However, it is worth noting that the organization of work in managed fisheries is guided by concepts such as equality, cooperation, and gender equity. The division of the group into teams, and the mastery of specialized knowledge about ecology, the behavior of animals, and the characteristics of the environment, have an impact on fishing productivity. Women's participation is highlighted in the assemblies, in fishing monitoring, and in fish processing (evisceration and cleaning) (Alencar *et al*. 2014). Managed pirarucu fishing conducted by riverain communities has raised the visibility of fisherwomen, guaranteeing their participation and recognizing them as productive agents in the artisanal fishing sector, acting under conditions of equality with men (Alencar and Sousa 2017).[kk]

[jj] For a detailed presentation and analysis of the situation regarding free, prior, and informed consultation according to ILO Convention 169 in South America, besides the above-mentioned site of the Observatory, see also a special issue on the subject by the Brazilian NGO Socioenvironmental Institute at https://especiais.socioambiental.org/inst/esp/consulta_previa/index.html.

[kk] For a detailed discussion about women's participation in fishing in the Solimôes River, a careful and extended review of numerous studies, focusing on issues such as sexual division of labor, gendered knowledge, visibility of women's contributions, and the like, would dispense with a value chain analysis, since the studies already bring first hand qualitative data on the contributions of women and men of different generations (childhood, youth, and old age), that would help both identify gaps of inequality

31.2.7. Recreational fishing and territorial management in Indigenous lands, Amazonas, Brazil

Recreational fishing in Brazil is mostly conducted without any planning, monitoring, or surveillance, within the framework of a competitive model, which has led to the overexploitation of some rivers. The collapse of traditional recreational fish stocks drove fishers to unexploited regions, especially protected areas and Indigenous lands.

The Amazon is one of the world's most popular destinations for recreational fishing, especially sport fishing tourism. To prevent uncontrolled activity and in search of opportunities to promote territorial management, Indigenous peoples of the Rio Negro in Amazonas State, Brazil, developed an innovative approach. This approach is based on proper consultation with the interested communities, systematic measurement of socio-environmental impact, and specific business arrangements to share the economic benefits of the activity, under Indigenous governance.

FAO defines recreational fishing as "fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold" (FAO 2012). It means that, besides responsible fishing practices and the sustainability of the activities, the activity must not impact food security, for example. In this sense, the National Policy for Environmental and Territorial Management of Indigenous Lands (PNGATI) (Decree 7.747/2012) regulates the insertion of productive activities and/or tourism in Indigenous lands, provided these activities can contribute to territorial management, household sustainability, and that: i) they are of collective interest, ii) they are environmentally secure, and iii) the right of the peoples to live according to their livelihoods and customs are respected. PNGATI recognizes the right of Indigenous communities in promoting productive activities and in establishing partnerships, settling old doubts in relation to the Federal Constitution's text itself and the Statute of Indigenous Peoples, still in force.

The Marié River is one of the boundaries between the counties of São Gabriel da Cachoeira and Santa Isabel do Rio Negro; a transition zone between the regions known as the middle and upper Rio Negro. Besides being fundamental for Indigenous communities' food security, the area is also of great importance for culture, livelihoods, and local knowledge. Considered a "fish abundant" river in, the Marié River is under extreme pressure from commercial fishing, which is frequently performed in an irresponsible or illegal way on vessels from other communities and the town of São Gabriel da Cachoeira, using high-impact equipment and without following any management rules. Studies have been performed in response to a recommendation from the Office of the Public Attorney of Amazonas State (MPF-AM), following a complaint by the Federation of Indigenous Organizations of the Negro River (FOIRN), denouncing irregular operations of recreational fishing in the Marié River (Figure 31.5).

Once the communities expressed interest in recreational fishing tourism in their traditionally occupied land, studies were conducted on the social and environmental sustainability of fishing, food security, Indigenous communities' livelihoods, and their customary rules of natural resource management, split into two major stages in 2013. In both stages, environmental surveys were performed (e.g., using an expedition for data collection on the Marié River to assess the fishing stocks, the potential of the river for recreational fishing, and the environmental impact of the activity), and social and cultural surveys were carried out (interviews and workshops with the Association of the Indigenous Communities of the Lower Negro River (ACIBRN), both in the communities and in the town of São Gabriel da Cachoeira). All activities were attended by leaders of the communities, employees of the National Foundation of the Indian (Funai), and the Brazilian Institute of Environ-

between contributions and access to benefits, and design even more adequate and sustainable technical and financial assistance programs.

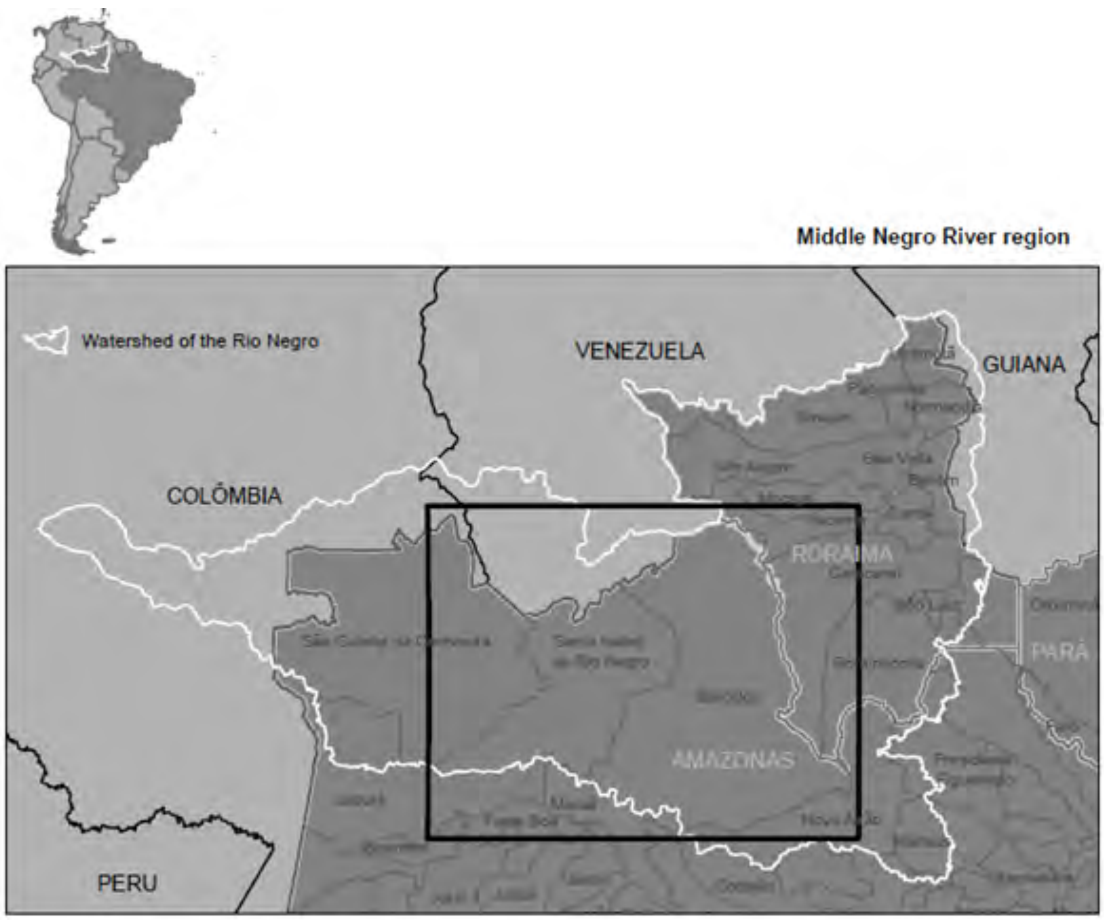


Figure 31.5. Middle Rio Negro Region

ment and Renewable Natural Resources (Ibama), with the support of the NGO Socioenvironmental Institute (ISA 2012).

In the first stage, the objectives were i) to assess the communities' degree of understanding of recreational fishing tourism, regarding impact studies and the necessary steps to regulate the activity; ii) to survey the social and economic dynamics, characterize the fishing activities, and map the areas and types of resources used.

In the second stage, the objective was to perform community workshops with broad household participation in the 14 communities, to discuss the elaboration of a fishing management plan for the region, strengthening local rules and incorporating new elements for managing the territory and preserving fish stocks, including recreational fishing tourism as an economical alternative.

After integrated analysis of the collected data, discussions, and workshops, the Marié River was considered suitable for recreational fishing tourism. The assessment considered both the environmental aspects as well as the social and cultural aspects. It concluded that recreational fishing tourism could be performed without any harm to the livelihoods of the local communities and had the potential to generate local revenue, and, more importantly, promote territorial management.

The recreational fishing project for the Marié River is recognized as a good example, with world-record fish landings and positive social impact. It has led to joint management and transparency among companies and communities, equivalent benefit sharing, collective investment in the 14 communities, hiring and capacity-building of local workers, maintenance of an integrated management program, surveillance and monitoring of fishing, infrastructure, and low-impact operations that use solar energy and residue treatment methods, and annual fishing expeditions accompanied by competent agencies; all activities independently supported by fishing tourism revenue.

The studies, consultations, management agreements, and business arrangements performed at the Marié River may be a model for the regulation of fishing activities in protected areas, Indigenous lands, and local communities' territories. It was fundamental to establish partnerships and to define the responsibilities and commitments of each stakeholder at all steps in the process. Recreational fishing tourism on the Marié River is "community-based tourism", collaborating towards sustainability and better management of the Indigenous territory.

When looking at indicators of conservation, the Marié River performs extremely well; this can be attributed to the relatively recent advent of recreational fishing tourism (since 2008). In rivers where recreational fishing tourism has been in place longer, particularly in disorganized forms and/or without monitoring programs, there are fewer landings of large fish, indicating that this activity is unsustainable without the proper guidelines and policies. Qualitative and quantitative indicators are measured at the start and monitored regularly to avoid overexploitation.

Even if all recommended steps have been taken and safeguards are in place to ensure environmentally- and socially-safe fisheries, the activity should be rigorously monitored and evaluated to assess whether management measures are sufficient. In addition, the project arranges bi-annual meetings of the management council, chaired by ACIBRN, the 14 communities, and the partner company to discuss the project and any issues.

This social impact model has been replicated, and there are four sportfishing tourism projects in the Rio Negro, covering the Middle Rio Negro I, Middle Rio Negro II, Jurubaxi-Tea, and Uneuixi Indigenous lands. They respect the peoples' own form of organization, revert resources to collective demands, and contribute directly to the monitoring and protection of the territory. This results in unique conservation conditions and experiences for visitors. Thus, Indigenous tourism initiatives stand against the threats of invasion and disorderly exploitation and contribute to the permanence of families within the territory.

The COVID-19 pandemic has highlighted a number of structural weaknesses in the Amazon, and the region has been the most severely impacted in South America. Visitation activities on Indigenous lands have been suspended, as determined by Funai. Indigenous communities are discussing contingency plans to ensure protection and public health, as well as economic recovery. Despite the ongoing health and economic crises, the experience of the Marié River and other tourism initiatives in the Rio Negro demonstrate the importance of Indigenous governance at all levels and in all cases, even in the management of emergency funds. For the sustainability of Indigenous lands, it is critical to promote productive initiatives aligned with the objectives of territorial management and structured in business arrangements that guarantee truly autonomous Indigenous governance.

31.3. Discussion

The territorial management initiatives presented in the previous section express, more or less explicitly, one or more of the following strategies:[11]

- Use of ethnoinstruments for socioenvironmental assessments, diagnostics, and planning/zoning (see 31.2.1 - 31.2.4, 31.2.7).
- Construction of life plans, where the use or management of natural resources are considered, and agreements and self-governance for

[11] See Smith & Guimarães for a general outlook. It is tempting to organize the points below along the life cycle of a project, and, by extension, of territorial management. Although this is not the case, one can read the list in terms of an underlying sequence of actions, from diagnosis through to planning and collaborative knowledge building to the effective implementation of activities at various scales (from local to national), which is generally followed by the development of territorial management; what betrays its rationality.

the implementation of the plans is established (see 31.2.1 - 31.2.4).

- Strengthening the role of Indigenous people, at a local and/or regional scale, to act as multipliers and technical advisers on territorial and environmental management in villages and communities (e.g., agroforestry, socio-environmental management, and/or environmental agents) (see 31.2.2 - 31.2.4, 31.2.7).
- Promoting connections between local and scientific knowledge in the generation of methodological and technological innovations, and management tools appropriate to local socio-environmental specificities (all sections).
- Elaboration and implementation of local initiatives (agroforestry systems, management of species of flora and fauna), and reconstitution and/or maintenance of local agrobiodiversity, associated (or not) with income generation (i.e., initiatives focused on production) (see 31.2.6 and 31.2.7).
- Elaboration and implementation of actions to improve territorial protection, with local surveillance and monitoring strategies, and approaches to surrounding areas (see 31.2.1 - 31.2.4, 31.2.6, 31.2.7).
- Institutional strengthening of Indigenous, Afro-descendant, and other local communities' associations to build and execute management plans, and carry out social control of public policies (Indigenous, environmental, education, health, and income transfer) (all sections).
- Elaboration and implementation of collective autonomous protocols for consulting peoples and communities, potentially by development schemes (see 31.2.5, 31.2.7).

It is worth mentioning two more strategies, although the initiatives presented in the previous section do not explicitly allude to them, because they are known to occur and generate positive conservation and social justice outcomes: i) elaboration and implementation of local initiatives for restoration and recovery of degraded landscapes and waters, associated or not with income generation; and ii) promoting programs and funds to support community business initiatives, with particular attention to building management capacity; creating business arrangements and contracts integrated with communities' established social organizations; and with a view toward implementing territorial management and generating expected social impacts (e.g., autonomy, resources shared and managed according to agreed governance). All the above-mentioned strategies amount to what we can call territorial management and development approach.

Clearly, conservation efforts in the Amazon cannot succeed without the active participation of peoples and communities that live in the region who, through their knowledge and ways of caring for the territory, have developed innovative models and arrangements responsible for the protection and sustainable development of a significant portion of the biome. From the seminal study by Ferreira *et al.* (2005) to more recent contributions (Baragwanath and Bayi, 2020),[mm] data supports communities' exercise of autonomy in the management of their territories as an effective strategy to halt deforestation and promote the conservation of the Amazon's sociobiodiversity, thus mitigating climate change and strengthening citizenship and the political role of local peoples and communities in the region. When and where Indigenous peoples and local communities have secure rights to land and to manage their territories autonomously, there tends to be less deforestation as compared to other management regimes.[nn] Research has also shown that secure and enforced

[mm] It is worth citing parts of the results and discussion of the Baragwanath and Bayi (2020) study focusing on the Brazilian Amazon: "Our results show strong effects of collective property rights on deforestation. Homologation [of Indigenous Land] is responsible for about a 2-percentage point decrease in deforestation right at the border. Considering that the baseline levels of deforestation in our sample are around 3%, this represents a 66% decrease in deforestation. Given that this is a local average treatment effect, we consider this to be a very strong finding. [...] We find that granting property rights significantly reduces the levels of deforestation inside indigenous territories, and the results are of significant orders of magnitude. The complete standstill in homologation of indigenous lands which began with the Temer administration and has continued under President Bolsonaro could be responsible for an extra 1.5 million hectares of deforestation per year" (: 20498-20499).

[nn] For an analysis of the growing body of evidence linking community territorial rights with healthier environment and lower carbon dioxide (CO_2) emissions from deforestation and forest degradation in Africa, Asia and Latin America, see Stevens *et al.* 2014.

land tenure is also cost-effective, providing economic and social benefits at a reasonable financial cost (Gray *et al.* 2015).

As the experiences presented indicate – whether acknowledged through different legal and administrative arrangements, governance, and limits (given the distinct national frameworks), through identity belonging, or through a collective project – territories represent coordination spaces where innovative and/or renovated forms of governance have been developed and implemented. For those who live in them and even for those who do not, they offer a unique opportunity to design projects for collective well-being in a sustainable world. They may provide economic, social, and environmental services that are essential to ensure peace, social cohesion, and sustainability (Caron 2017). Territories provide a framework for social, technological, and organizational resource management, through collective and individual innovation; the organization of economic activities and services, in particular ecological ones; the valorization of local and patrimonial knowledge and resources; and the design of public policies (Valette *et al.* 2017).

Even before the Sustainable Development Goals were adopted in 2015, formally recognized social territories in the Amazon have represented both frameworks and active vectors to address those goals. As the majority of experiences point out, because of their capacity to articulate collective and public actions (since people are grounded in them), social territories provide an opportunity to strengthen the capacity of multiple stakeholders with divergent views and vested interests, to coordinate and collaboratively identify priorities and actions for integrating environmental, social, and economic objectives while addressing trade-offs. They demonstrate the capacity to regulate economic dynamics while taking into account social and environmental concerns and participating in the delivery of local, regional, national, and global public goods (Caron *et al.* 2017).

Understood as the capacity of a social group to anticipate and manage the evolution of their territory (see 31.2.1 - 31.2.4), territorial management and development may contribute to the design of public policies at larger scales (see 31.2.1, 31.2.3, and 31.2.6), aiming to support local dynamics through appropriate legislation and incentives, or make relevant decisions at regional and national levels (sections 2.1 - 2.4). In other words, the territory is a relevant scale to address both local and global challenges related to deforestation, climate change, erosion of cultural and biological diversity (including linguistic diversity), renewal of natural resources, anticipation of migratory processes, organization of exchanges, and security (Caron *et al.* 2017).

Territorial management and development approaches are particularly relevant to strengthening governance and the management of lands and natural resources by Indigenous territories, local communities, and stakeholders in and around protected areas. The few experiences we have presented here illustrate the importance and benefits of such approaches, in particular to address environmental concerns in the Amazon region, by generating a barrier to deforestation in the case of protected areas, Indigenous lands, and other traditional territories; and contributing to the sustainable use and valorization of biodiversity in post-pioneer agricultural areas.

31.4. Conclusions

It was not our intent to compile an exhaustive list of initiatives led by Indigenous peoples, local communities, and their institutional partners that point to a more socially and environmentally fair, equal, diverse, rich, conservation-friendly, and livable future. However, we have provided a generous overview of experiments and trends deeply rooted in acknowledgment of the constructive roles protected areas, Indigenous lands, and local communities' territories play in the Amazon Basin, and in the full respect and strengthening of these peoples' territorial and other rights.

This chapter reiterates and reaffirms claims made in other chapters (e.g., Chapter 16), and may not offer what experts in the Amazon consider a very innovative perspective. We argue that any reiteration has a pedagogic value in emphasizing the issues that are effectively relevant, and note that the aim of this report is to reach beyond a community of experts, to other stakeholders for whom what looks like more-of-the-same to us might come, if not as a surprise, as knowledge in need of an echo. Innovation is always a matter of perspective and positionality.

We conclude by reemphasizing that there is no future for the Amazon without uplifting the voices and rights of its peoples and their territorially-based lifestyles, and that it is imperative to appreciate conservation-friendly creative alternatives based on the full respect and strengthening of territorial rights that are currently being developed in the region. Furthermore, as already mentioned, in the near future partnerships will be crucial to develop sustainable finance for Indigenous and local territorial management, based on respect for rights, transparent financial management, and effective implementation for nature and people. In a context where conflict between Indigenous and local communities and regional, national and sub-national development policies is rife and drives degradation, the future will require political will to uphold these peoples' rights. Throughout the Amazon, it will be essential for Indigenous and local communities' to participate in the indispensable process of transformation of socio-environmental justice required to address deadly threats.

31.5. Recommendations

In an effort to continue the discussion and synthesize lessons learned from the experiences presented, which point to a horizon of anticolonial territorial management and development, we present the following recommendations for the construction of a socially-just and environmentally-sustainable future for the Amazon:

- Strengthen legislation that protects Indigenous peoples and local communities' land rights in all Amazonian countries.
- Acknowledge the role of protected areas (broadly understood) in climate change mitigation and adaptation efforts.
- Recognize and value Indigenous and local knowledge regimes integrated with territorial autonomy.
- Develop policies, programs, and funds to support territorial management and development, guaranteeing the conditions for community social organization and the elaboration and implementation of territorial management instruments by communities.
- Incorporate conservation and sustainable management objectives for protected areas, Indigenous lands, and local communities' territories in investment plans and legislation related to the development of particular sectors in all Amazonian countries.
- Anticipate the design and implementation of biocultural and/or ethnoecological corridors connecting and integrating different types of protected areas and other forms of protection.
- Strengthen the connection between social territories and municipal or departmental headquarters to promote networks and supply chains to support agro-extractivist production and commercialization.
- Implement inclusive public policies related to economic development, based on socio-biodiverse products and environmental services at micro-regional and local scales.
- Seek a progressive transition of financing models associated with territorial management and development towards arrangements that allow autonomous management aligned with local practices to manage resources, thus ensuring the direct, effective, and daily participation of Amazonian peoples and communities.
- Support the organization and institutional strengthening of local social actors in order to strengthen participatory management of territories and promote implementation and integration of public policies.
- Strengthen community organizations and local institutions for qualified participation in the decision-making processes that affect them.
- Recognize the important contributions of Indigenous and local communities' women's organizations in knowledge systems, territorial management, stewardship of specific resources, and defense of their territories and the Amazon as a whole, guaranteeing special support to women's participation in decision-making and management initiatives.

- Work with youth organizations, connecting social movements and initiatives across Amazonian countries.

31.6 References

Abramovay R. 2003. O futuro das regiões rurais. UFRGS Editora.

Alarcón WD. 2007. Bilingüismo indígena en Colombia. *GIST--Education Learn Res J*: 24–38.

Almeida AWB. 2009. Universalização e localismo: movimentos sociais e crise dos padrões tradicionais de relação política na Amazônia. In: D'Incao MA., Silveira I. (Eds). A Amazônia e a Crise da Modernização. 2ªEd. Instituto de Ciências Sociais Aplicadas Museu Paraense Emílio Goeldi.

Almeida A. 2006. Os quilombolas e a base de foguetes de Alcântara, vol I. Brasilia: MMA.

Almeida AWB. 2008. Terras tradicionalmente ocupadas: processos de territorialização e movimentos sociais e uso comum". In: Terras de quilombo, terras indígenas, "babaçuais livre", "castanhais do povo", faixinais e fundos de pasto: terras tradicionalmente ocupadas. PGSCA/UFAM.

Almeida AWB de. 2019. As estratégias de exportação agromineral e a usurpação das terras tradicionalmente ocupadas: à guisa de Introdução. In: Mineração e Garimpo em Terras Tradicionalmente Ocupadas: conflitos sociais e mobilizações étnicas. PNCSA.

Almeida OT, Lorenzen K, and McGrath DG. 2009. Fishing agreements in the lower Amazon: for gain and restraint. *Fish Manag Ecol* **16**: 61–7.

Athayde S, Silva-Lugo J, Schmink M, *et al.* 2017. Reconnecting art and science for sustainability: learning from indigenous knowledge through participatory action-research in the Amazon. *Ecol Soc* **22**: art36.

Baragwanath K and Bayi E. 2020. Collective property rights reduce deforestation in the Brazilian Amazon. *Proc Natl Acad Sci* **117**: 20495–502.

Barreto Filho HT. 2020. The Amazon under Bolsonaro: Back to Conventional Frontier Economics—In Its Most Radical Version. *Soc Cult Anthropol*.

Barretto Filho HT. 2020. Bolsonaro, Meio Ambiente, Povos e Terras Indígenas e de Comunidades Tradicionais: uma visada a partir da Amazônia. *Cad Campo (São Paulo - 1991)* **29**: e178663.

Barretto F and Henyo T. 2018. Reparação e Descolonização como Eixos da Política Indigenista: um trecho original do documento-base da 1ª Conferência Nacional de Política Indigenista Vukápanavo. *Rev Teren* **1**: 80–106.

Beduschi LC and Abramovay R. 2003. Desafios para a gestão territorial do desenvolvimento sustentável no Brasil. In: Congresso Brasileiro de Economia e Sociologia Rural (SOBER), de 27 a 30 de Julho de 2003, Juiz de Fora-MG.

Bengoa J. 2009. ?` Una segunda etapa de la Emergencia Ind{\'\i}gena en América Latina? *Cuad Antropol Soc*: 7–22.

Bourdieu P, Curto DR, Domingos N, and Jerónimo MB. 1989. O poder simbólico.

Branco GLC. Las mujeres como recuperadoras del territorio en Salitre-Costa Rica. *Tesis Maest Académica en Antropol Soc*.

Brasil C. 2014. Comissão Nacional da Verdade. In: Relatório. Volume II: Textos temáticos. CNV. 416 p. (Relatório da Comissão Nacional da Verdade; v. 2).

Campos-Silva JV and Peres CA. 2016. Community-based management induces rapid recovery of a high-value tropical freshwater fishery. *Sci Rep* **6**: 34745.

Caron P. 2017. Entre promesses et risques, l'usage du mot territoire dans la pensée du développement agricole. In: Caron P, Valette E, Wassenaar T, *et al.* (Eds). Des territoires vivants pour transformer le monde. Versailles: Ed. Quae. Agricultures et défis du monde.

Castello L. 2004. A Method to Count Pirarucu Arapaima gigas : Fishers, Assessment, and Management. *North Am J Fish Manag* **24**: 379–89.

Conklin BA and Graham LR. 2009. The Shifting Middle Ground: Amazonian Indians and Eco-Politics. *Am Anthropol* **97**: 695–710.

Cunha MC da and Almeida MWB de. 2000. Indigenous People, Traditional People, and Conservation in the Amazon. *Daedalus* **129**: 315–38.

Del-Campo H Del and Wali A. 2007. Applying Asset Mapping to Protected Area Planning and Management in the Cordillera Azul National Park, Peru. *Ethnobot Res Appl* **5**: 025.

Escobar A. 2020. Pluriversal Politics. The Real and the Possible. In: Latin America in Translation. Durham: Duke University Press.

FAO. 2012. Recreational Fisheries. In: Hilborn R, Hilborn U (Eds). Technical guidelines for responsible fisheries. No 13.

Ferreira LV, Venticinque E, and Almeida S. 2005. O desmatamento na Amazônia e a importância das áreas protegidas. *Estud Avançados* **19**: 157–66.

Frank MA. 2018. Mujeres Indígenas del Amazonas: defendiendo a la Madre Tierrahttps://www.culturalsurvival.org/es/publications/cultural-survival-quarterly/mujeres-indigenas-del-amazonas-defendiendo-la-madre-0. Viewed

Gaia Amazonas. 2020. Documento de trabajo en construcción. El Macroterritorio de la Gente de Afinidad de Yuruparí: escenario de gobernanza indígena y coordinación interinstitucional en el noreste amazónico colombiano.

Gaioso AV. 2014. Tempo da Cabaça: etnografia da história social de uma comunidade quilombola-MA. In: Tese de Doutorado em Antropologia Social. Universidade Federal da Bahia.

Garcia Llorens M. 2008. La Construcción de la Realidad según Alan García.https://argumentos-historico.iep.org.pe/articulos/la-construccion-de-la-realidad-segun-alan-garcia/. Viewed

García A. 2007. El síndrome del perro del hortelanohttps://indigenasdelperu.files.wordpress.com/2015/09/26539211-alan-garcia-perez-y-el-perro-del-hortelano.pdf . Viewed

Gonzalez Casanova P. 1965. Internal colonialism and national development. *Stud Comp Int Dev* **1**: 27–37.

Gray E, Veit PG, Altamirano JC, *et al.* 2015. The Economic Costs and Benefits of Securing Community Forest Tenure: Evidence from Brazil and Guatemala.

Hale CR. 2005. Neoliberal Multiculturalism: The Remaking of Cultural Rights and Racial Dominance in Central America. *Polit Leg Anthropol Rev* **28**: 10–28.

Harvey D. 2003. Accumulation by Disposession. In: The New Imperialism. Oxford University Press.

Hernández FJ. 2018. Los defensores de la vida contra los proyectos de muerte: Resistencias y articulaciones frente a la industria extractiva en la Sierra Norte de Puebla. *Bajo el Volcán* **18**: 109–43.

IDEAM. 2019. Monitoreo de bosques y recursos forestales. http://www.ideam.gov.co/web/ecosistemas/bosques-recurso-forestal.

ISA. Instituto Socioambiental. https://www.socioambiental.org/en

Hobsbawm E. 1995. Era dos extremos: o breve século XX. Editora Companhia das Letras.

Krenak A. 2019. Ideias para adiar o fim do mundo. Editora Companhia das Letras.

Krenak A. 2020. A vida não é útil. Companhia das Letras.

Kretzmann J and McKnight JP. 1996. Assets-based community development. *Natl Civ Rev* **85**: 23–30.

Lima LG de and Batista V da S. 2012. Estudos etnoictiológicos sobre o pirarucu Arapaima gigas na Amazônia Central. *Acta Amaz* **42**: 337–44.

Little PE. 2018. Territórios sociais e povos tradicionais no Brasil: por uma antropologia da territorialidade. *Anuário Antropológico* **28**: 251–290.

Little PE. 2006. Gestão Territorial em Terras Indígenas: definição de conceitos e proposta de diretrizes. --SEMA-AC, Secretaria Extraordinária dos Povos Indígenas--SEPI-AC e Agência da GTZ no Brasil--GTZ. Rio Branco, Acre.

Little PE. 2010. Conhecimentos tradicionais para o século XXI: etnografias da intercientificidade. IEB, Instituto Internacional de Educação do Brasil.

Llorente JC and Sacona U. 2012. Investigación aplicada a la educación intercultural bilingüe: Algunas reflexiones epistemológicas. Helsinki: Instituto de Ciencias del Comportamiento.

Mathie A and Cunningham G. 2003. From clients to citizens: Asset-based Community Development as a strategy for community-driven development. *Dev Pract* **13**: 474–86.

Miller CA and Wyborn C. 2018. Co-production in global sustainability: histories and theories. *Environ Sci Policy*.

Molina Betancur CM. 2012. La autonomía educativa indígena en Colombia. *Vniversitas* **61**: 261–92.

Moreira PF, Gamu JK, Inoue CYA, *et al.* 2019. South–South Transnational Advocacy: Mobilizing Against Brazilian Dams in the Peruvian Amazon. *Glob Environ Polit* **19**: 77–98.

Ontiveros LS, Munro PG, and Lourdes Melo Zurita M de. 2018. Proyectos de Muerte: Energy justice conflicts on Mexico's unconventional gas frontier. *Extr Ind Soc*.

Oviedo AFP and Bursztyn M. 2017. Descentralização E Gestão Da Pesca Na Amazônia Brasileira: Direitos Sobre Recursos E Responsabilidades. *Ambient Soc* **20**: 169–90.

Plan de Salvaguarda del Pueblo Koreguaje. 2014. Asociación de Autoridades Tradicionales del Consejo Regional Indígena del Orteguaza Medio Caquetá - CRIOMC Viewed

RAISG. 2012. Amazonia Bajo Presion. RAISG Red Amazónica de Información Socioambiental Georreferenciada.

Real VI and Ruiz DC. 2019. Las mujeres indígenas amazónicas: Actoras emergentes en las relaciones Estado - organizaciones indígenas amazónicas, durante el gobierno de Alianza País en el Ecuador. *P* **18**.

Rivera Cusicanqui S. 2013. Ch'ixinakax utxiwa. Una reflexión sobre prácticas y discursos descolonizadores. Tinta limon.

Rivera Cusicanqui, S. 2014. Más allá del dolor y del folklor. Os mil nomes da Gaia. Do Antropoceno à Idade da Terra. Coloquio Internacional, Casa de Rui Barbosa. Rio de Janeiro. Recuperada en www.osmilnomesdagaia.eco.br.

Rivera Cusicanqui S. 2015. Mito y desarrollo en Bolivia: el giro colonial del gobierno del MAS. Piedra Rota.

Rodríguez C and Hammen M van der. 2000. Biodiversidad y manejo sustentables del bosque tropical por los indígenas Yukuna y Matapi de la Amazonía colombiana. In: Editors S del H (Ed). El Vuelo de la Serpiente. Desarrollo sostenible en la América prehispánica. Bogotá, Colombia.

Sepúlveda G. 1996. Interculturalidad y construcción del conocimiento. *Educ e Intercult en los Andes y la Amaz*: 93–104.

Silva NMG da, Addor F, Lianza S, and Pereira H dos S. 2020. O debate sobre a tecnologia social na Amazônia: a experiência do manejo participativo do pirarucu. *Terceira Margem Amaz* **6**: 79–91.

Smith M and Guimarães MA. 2010. Gestão ambiental e territorial de terras indígenas: reflexões sobre a construção de uma nova política indigenista. *Encontro da assoc nac pósgraduação e pesqui em Ambient E Soc* **5**.

Sobreiro T. 2015. Can urban migration contribute to rural resistance? Indigenous mobilization in the Middle Rio Negro, Amazonas, Brazil. *J Peasant Stud* **42**: 1241–61.

Sobreiro T. 2015. Urban-Rural Livelihoods, Fishing Conflicts and Indigenous Movements in the Middle Rio Negro Region of the Brazilian Amazon. *Bull Lat Am Res* **34**: 53–69.

Stavenhagen R. 1985. Etnodesenvolvimento: uma dimensão ignorada no pensamento desenvolvimentista. *anuário antropológico* **9**: 11–44.

Stevens C, Winterbottom R, Springer J, and Reytar K. 2014. Securing Rights, Combating Climate Change: How Strengthening Community Forest Rights Mitigates Climate Change. Washington, DC: World Resources Institute. World Resources Institute.

Svampa M. 2019. Las fronteras del neoextractivismo en América Latina: conflictos socioambientales, giro ecoterritorial y nuevas dependencias. transcript Verlag.

Valette E, Caron P, d'Eeckenbrugge GC, and Wassenaar T. 2017. Conclusion générale et perspectives. *Des Territ vivants pour Transform le monde*: 263.

Wali A, Alvira D, Tallman PS, *et al.* 2017. A new approach to conservation: using community empowerment for sustainable well-being. *Ecol Soc* **22**: art6.

Walsh C. 2009. Interculturalidad crítica y educación intercultural. *Inst Int Integr del Conv Andrés Bello*: 9–11.

Yamada EM, Grupioni LDB, and Garzón BR. 2019. Protocolos autônomos de consulta e consentimento: guia de orientações. RCA.

Amazon Assessment Report 2021

Cross-Chapter Box

Legacy from the Ancestors: Amazonian Biocultural Landscapes and Global Sustainability in a Post-COVID-19 World

Assembleia Extraordinária e Ordinária Eleitoral da Associação das Mulheres Indígenas Sateré Mawé (AMISM)
(Foto: Wérica Lima /Amazônia Real)

INDEX

CC2.1 INTRODUCTION CC2.2

CC2.2 THE AMAZON SACRED HEADWATERS INITIATIVE CC2.3

CC2.3 ALLY GUAYUSA COOPERATIVE CC2.4

CC2.4 THE AMAZON HOPES COLLECTIVE CC2.4

CC2.5 RECOMMENDATIONS CC2.4

CC2.6 REFERENCES CC2.5

Cross-Chapter Box: Legacy from the Ancestors: Amazonian Biocultural Landscapes and Global Sustainability in a Post-COVID-19 World

Simone Athayde[a], Eduardo Neves[b], Glenn Shepard[c] and Michael Heckenberger[d]

CC2.1 Introduction

Did you know that chocolate, peanuts, manioc, chili peppers, Brazil nut, açai, and many other regionally and globally important foods were first managed or domesticated by Amazonian Indigenous peoples? Here, we explain how Indigenous peoples have shaped forest landscapes across the Amazon, and why they remain key partners for preserving and sustainably using biodiversity.

Indigenous peoples have interacted with Amazonian ecosystems for thousands of years, in some cases shaping the species composition of forests to suit human needs without disrupting ecological services (Posey 1985; Balée 1989; Balée 2010; Levis *et al.* 2018; Flores and Levis 2021). Afro-descendant and riverine communities have also sustainably managed Amazonian landscapes. Such biocultural landscapes result from long-term co-evolution between biological, sociocultural and linguistic diversity (Heckenberger 2010; Athayde *et al.* 2017).

Indigenous and Afro-descendant management led to the domestication of globally important crops and food-producing forest landscapes that provide sustenance and income to millions of people. These include cultivated crops like manioc (*Manihot esculenta*), peanuts (*Arachis hypogaea*), and chili peppers (*Capsicum* spp.), as well as forest products like chocolate *(Theobroma cacao*), Brazil nut (*Bertholletia excelsa*), açaí (*Euterpe* spp.), peach palm (*Bactris gasipaes*), guaraná (*Paullinia cupana*), cupuaçu (*Theobroma grandiflorum*) and dozens of others (Clement *et al.* 2015; Fausto and Neves 2018; Neves and Heckenberger 2019).

Management strategies that have shaped Amazonian biocultural diversity since the ancient past, and that are still practiced by Indigenous peoples and local communities (IPLCs), include (Figure CC2.1):

1) Protection, transportation, and transplanting of useful species;
2) Attraction of animal dispersers;
3) Phenotype selection;
4) Fire management;
5) Soil improvement; and
6) Weeding (see Levis *et al.* 2018).

Current IPLCs' practices upon Amazonian ecosystems call for new approaches to biodiversity conservation that recognize IPLC's knowledge and rights and include them in management and policy making (Franco-Moraes *et al.* 2019; Shepard *et al.* 2020; Cunha *et al.* 2021). A growing recognition of the role of ancient and Amazonian biocultural landscapes managed and protected by IPLCs have become islands of forest cover, biodiversity, and detailed traditional knowledge that could provide solutions to global food security, climate stability, and bioeconomics to address overlapping environmental, economic, and health crises (Flores and Levis 2021; Chapter 30). Here, we provide three examples of Indigenous-led projects promoting sustainable development of Amazonian biocultural landscapes: the *Amazon Sacred Headwaters* initiative

[a] Kimberly Green, Latin American and Caribbean Center and Department of Global and Sociocultural Studies, Florida International University, 11200 SW 8th Street Miami, USA, sathayde@fiu.edu
[b] Laboratório de Arqueologia dos Trópicos, Museu de Arqueologia e Etnologia, Universidade de São Paulo.Av. Prof. Almeida Prado, 1466, Cidade Universitária - São Paulo SP 05508-070, Brasil
[c] Museu Paraense Emílio Goeldi (MPEG), 376 Avenida Magalhães Barata, Belém PA, Brasil
[d] University of Florida, Gainesville, FL 32611

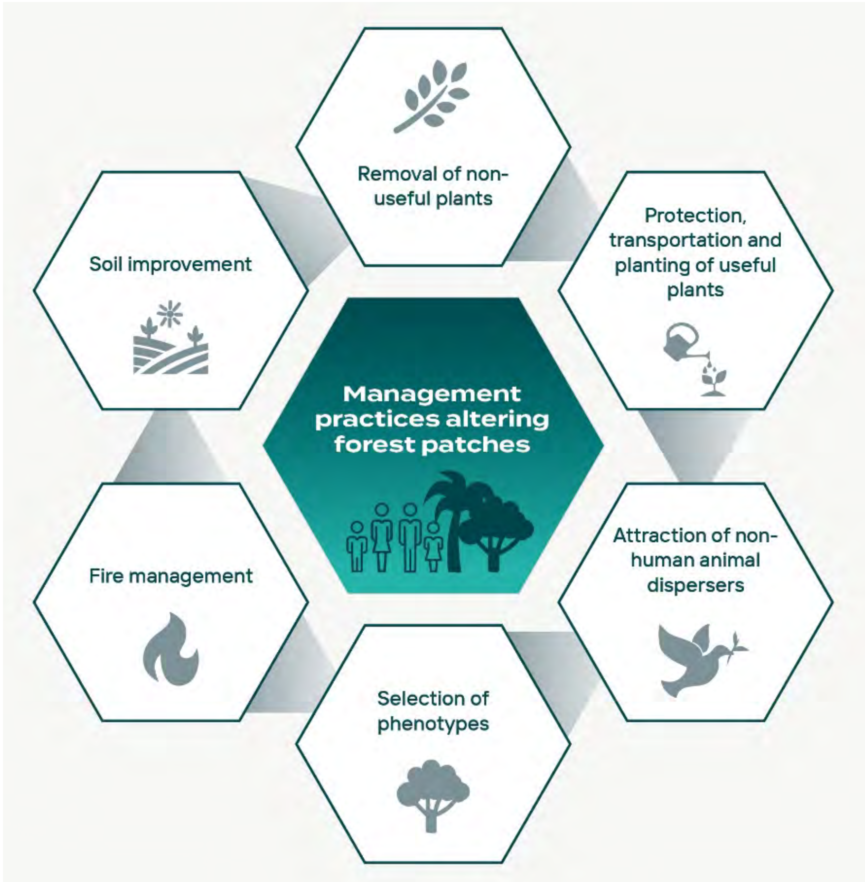


Figure CC2.1 Indigenous management practices impacting biocultural diversity and food production in the Amazon. Adapted from (Levis et al. 2018).

in Ecuador-Peru; the *Ally Guayusa Cooperative* in Ecuador; and the *Amazon Hopes Collective* in the Upper Xingu in Brazil.

CC2.2 The Amazon Sacred Headwaters Initiative

The *Amazon Sacred Headwaters Initiative* is building a shared vision among different stakeholders to establish a bi-national protected region between Peru and Ecuador, off-limits to oil drilling and industrial resource extraction and governed in accordance with Indigenous principles of cooperation and a mutual human-Earth relationship.[1] The initiative is led by country-based and basin-wide Indigenous federations and associations,[2] in partnership with the Pachamama Alliance and Fundación Pachamama, who have joined efforts to permanently protect 30 million hectares (74 million acres) of tropical rainforests in the ancestral territory of over 20 Indigenous peoples, some living in voluntary isolation. It also harbors nearly 6 billion tons of carbon in undeveloped oil and gas reserves and standing forests. Similar to the "Green New Deal," the initiative seeks to promote renewable energy (mainly through community-solar initiatives), reduce fossil fuel dependence, and create a

[1] Amazon Sacred Headwaters Initiative | Permanent protection for the Amazon.
[2] Confederation of Indigenous Nationalities of Ecuador (CONFENIAE); Asociación Interétnica de Desarrollo de la Selva Peruana (AIDESEP); Organización de los Pueblos Indígenas del Oriente (ORPIO) and Coordinadora de las Organizaciones Indígenas de la Cuenca Amazónica (COICA).

more just economic transition recognizing Indigenous knowledge and societies.

CC2.3 Ally Guayusa Cooperative

In Ecuador, the Kichwa Indigenous people established the *Ally Guayusa Cooperative*[3] to produce, harvest, process, and sell organic guayusa (*Ilex guayusa*) tea for local and international markets. With a population of 55,000, the Kichwa live in a territory of more than 1 million hectares between the Andean foothills and the Amazonian lowlands secured as a result of the 1992 Pastaza protest movement. Ongoing threats to their territory and culture include forest fires, large scale cattle ranching, road-building, industrial agriculture, illegal logging, mining, and oil and gas extraction. In response to these threats, Kichwa smallholder farmers, including strong women's leadership, are implementing innovative bioeconomy approaches for sustainable production and marketing of non-timber forest products. The Indigenous-owned business *Ally Guayusa* provides forest-based livelihoods while protecting biocultural diversity through partnerships with the Aliados Foundation and Lush Cosmetics Charity.

CC2.4 The Amazon Hopes Collective

The *Amazon Hopes Collective*[14] includes scholars, public agencies, and the Kuikuro Indigenous Association (AIKAX) of the Upper Xingu in Brazil. It builds on prior collaborative archeological research that documented large pre-Columbian populations with extensive landscape management (Heckenberger *et al.* 2008; Heckenberger 2020). The Upper Xingu and its Indigenous populations are threatened by encroachment from soy and cattle ranching, droughts, pollution, fires associated with climate change, and the COVID-19 pandemic. Collaborative biocultural heritage studies include state-of-the-art mapping technologies in the hands of Indigenous researchers that were adapted to monitor the COVID-19 pandemic using an ESRI ArcGIS dashboard. The Kuikuro are also applying these technologies to growing problems with forest fires caused by deforestation and climate change (Figure CC2.2). The project seeks to develop a "firewall'' by linking Indigenous peoples with the global community. These examples share common elements that can inspire pan-Amazonian and global policies:

- Strong Indigenous leadership and self-determination; valorization of Indigenous and local knowledge, languages, and biocultural practices; community and women's empowerment
- Coalitions and alliances between Indigenous peoples and diverse actors including scientists, governments, national and international NGOs, the private sector, and philanthropic organizations at local, regional, and global scales
- Integrated territorial management that sustains forest and river-based livelihoods, including economic solutions through the sustainable use of natural resources of local and global significance.

CC2.5 Recommendations

As resource scarcity, market engagement, and climate change have come to shape Amazonian livelihoods, Indigenous peoples and local communities have become key innovators in conservation and development projects, sustainable resource management, and territorial governance. The knowledge, products, and ecosystem services provided by Amazonian biocultural landscapes are intricately linked to global climate resiliency and to a post-carbon, post-COVID-19, equitable economy.

In this light, we close with four recommendations for policy-makers:

1. *Education and scientific communication*: Recognize Indigenous peoples' and local communities'

[3] https://news.mongabay.com/2020/05/ecuadors-kichwa-implement-innovative-approach-to-rainforest-conservation/
[4] More information on the project: https://www.pennywisefoundation.org/amazon-hopes-collective.html; https://storymaps.arcgis.com/stories/d13c50b64ada4e53856b3d4d64a08bcb

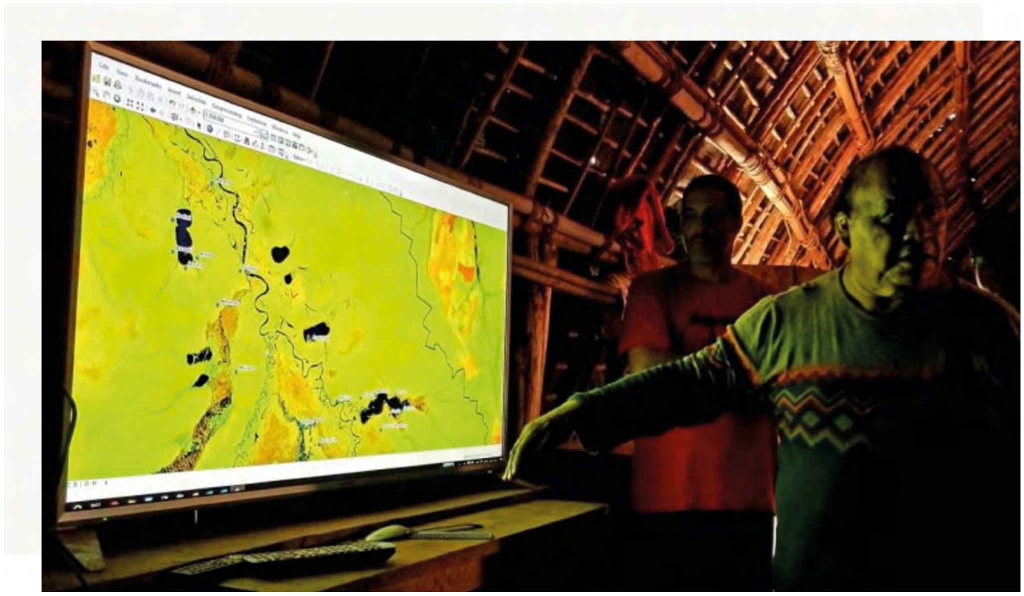


Figure CC2.2 The Amazon Hopes Collective project. Afukaká Kuikuro teaching about Kuikuro's forest and water management practices during a participatory mapping workshop. Photo by Michael Heckenberger.

role in the formation, management, and protection of biocultural landscapes in the Amazon; strengthen intercultural education programs that protect Indigenous and local languages and territories (Chapter 33).

2. *Territorial rights*: Guaranteeing territorial rights for Indigenous peoples and local communities is among the most important strategies for protecting biodiversity and biocultural landscapes in the Amazon, with significant implications for regional and global climate stability, as well as water and food security.

3. *Participation of Indigenous peoples and local communities*: Amazonian countries are pluricultural democratic societies, and their governments must guarantee the participation of Indigenous peoples and local communities in all decisions affecting their territories and livelihoods, providing timely access to reliable information and respecting their social organization and decision-making processes as outlined in the International Labour Organization's (ILO) Convention 169,[5] the Escazu agreement,[6] and the Leticia pact.[7]

4. *Bioeconomy and sociobiodiversity*: The current development model based on resource extraction must evolve towards a bioeconomy that sustains forest- and river-based livelihoods and protects biocultural diversity. International diplomacy and private sector initiatives must discourage and/or prohibit economic practices that result in deforestation, ecosystem degradation, and the violation of human and Indigenous rights.

CC2.6 References

Athayde S, Silva-Lugo J, Schmink M and Heckenberger M. 2017. The Same, but Different: Indigenous Knowledge Persistence and Change in the Brazilian Amazon. *Human Ecology* **45** (4): 533–544.

Balée W. 1989. The culture of Amazonian forests. Pages 1–21. In: Posey DA and Balée W, editors. Resource Management in Amazonia: Indigenous and Folk Strategies. New York Botanical Gardens, New York.

[5] https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C169
[6] https://www.cepal.org/en/escazuagreement
[7] https://es.mongabay.com/2019/09/cumbre-por-la-amazonia-colombia-pacto-de-leticia/

Balée W. 2013. Cultural forests of the Amazon: a historical ecology of people and their landscapes. Birminghan, The University of Alabama Press.

Clement CR, Denevan WM, M. J. Heckenberger MJ, *et al*. 2015. The domestication of Amazonia before European conquest. *Proceedings of the Royal Society of London B: Biological Sciences* **282** (1812):20150813.

Cunha MC, Magalhaes SB and Adams C. (orgs.). 2021. Povos Tradicionais e Biodiversidade no Brasil. Contribuições dos povos indígenas, quilombolas e comunidades tradicionais para a biodiversidade, políticas e ameaças. São Paulo: SBPC.

Fausto C and Neves E. 2018. Timeless Gardens: deep indigenous history and the making of biodiversity in the Amazon. In: Sanz N. 2018. Tropical Forest Conservation. Exploring Frameworks for Integrating Natural and Cultural Diversity for Sustainability, a Global Perspective Mexico: UNESCO.

Flores BM and Levis C. 2021. Ancient human-food feedback could boost tropical food security. *Science* **372** (6547): 1146-1147. DOI:10.1126/science.abh1806

Franco-Moraes J, Baniwa AFMB, Costa FRC *et al*. 2019. Historical landscape domestication in ancestral forests with nutrient-poor soils in northwestern Amazonia. *Forest Ecology and Management* **446**: 317-330.

Heckenberger M. 2020. Xingu Garden Cities: Amazonian Urban Landscapes, or What? In Landscapes of Preindustrial Urbanism, ed. Farhat G, pp. 225-261. Washington DC: Dumbarton Oaks.

Heckenberger MJ, Russell JC, Fausto C, *et al*. 2008. Pre-Columbian Urbanism, Anthropogenic Landscapes, and the Future of the Amazon. *Science* **321** (5893): 1214–17.

Levis C, Flores B, Moreira P, *et al*. 2018. How People Domesticated Amazonian Forests. *Frontiers in Ecology and Evolution* **5**:171.

Neves EG and Heckenberger MJ. 2019. The Call of the Wild: Rethinking Food Production in Ancient Amazonia. *Annual Review of Anthropology* **48**(1): 371-388.

Posey DA. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapó indians of the Brazilian Amazon. *Agroforest Syst* **3**: 139–158

Shepard GH Jr., Clement C, Lima HP, *et al*. 2020. Ancient and traditional agriculture in South America: Tropical lowlands. In R. Hazlitt (Ed.), Oxford Encylopedia of Agriculture and the Environment. Oxford: Oxford University Press.

Amazon Assessment Report 2021

Chapter 32

Milestones and challenges in the construction and expansion of participatory intercultural education in the Amazon

Escola Municipal de Ensino Fundamental Santa Terezinha, na Comunidade de Piquiatuba, Belterra
(Foto: Fábio Zuker/Amazônia Real)

INDEX

KEY MESSAGES 3
ABSTRACT 3
32.1 INTRODUCTION 4
32.2 TOWARDS UNDERSTANDING INTERCULTURAL EDUCATION (IE) AND CAPACITY BUILDING IN THE AMAZONIAN CONTEXT 5
32.3 DIVERSITY IN INTERCULTURAL EDUCATION AND CAPACITY BUILDING 7
32.4 RECOGNIZING PREVIOUS KNOWLEDGE AND EDUCATION CONTEXTS TO PROMOTE DIVERSITY 8
32.5 INTERCULTURAL EDUCATION IN PRACTICE: SIGNIFICANT CASES 8
32.5.1 Pedagogical and intercultural training in SENA, Vaupés: An approximation to cultural knowledge and practices. 9
32.5.2 Local research to strengthen autonomy and territorial governance 11
32.5.3. Indigenous intercultural education in the Rio Negro 13
32.5.4 Balcanes Farm at the Universidad de la Amazonia and its role in Intercultural Know-ledge Mediation (MIC) 16
32.5.5 Climate change as a strengthening theme and struggle for the Indigenous peoples of the Amazon 18
32.6 EMERGING REFLECTIONS AND IDENTIFIED NEEDS 19
32.7 CONCLUSION 21
32.8 RECOMMENDATIONS 22
32.9 REFERENCES 22
ANNEX 32.1 CASES & EXPERIENCES IN INTERCULTURAL EDUCATION IN THE AMAZON 24
.... 24
Objective 4+: Eco-cultural pluralism in quality education in the Ecuadorian Amazon 25
Intercultural bilingual education in the transition from primary to secondary school 25
Education and Indigenous territorial struggles: A study of the Sapara people's experiences with the education system in the Ecuadorian Amazon 26
Revival and regeneration of indigenous knowledge in intercultural bilingual teacher education: a study in the Ecuadorian Amazon 27
Contribution to the recovery of the know-ledge of the *chagra* of Indigenous communities of the department of Vaupés as a model of intervention in the production of self-consumption 28
Bilingual, culturally adapted education for Indigenous peoples in Brazil. 29

Graphical Abstract

Figure 1.A Examples of mainstream education's standardized practices (1), which can be overcome through intercultural education, including recognition of practices and knowledges (3), post-secondary education with intercultural tools (2), and dialogic learning connected to the territory (4).

Milestones and Challenges in the Construction and Expansion of a Participatory Intercultural Education in the Amazon

Sandra Frieri[*a], *Fernanda Bortolotto*[*b], *Gloria Amparo Rivera*[c], *André Baniwa*[d], *Bernardo Herrera*[a], *Clara van der Hammen*[e], *Paulo Moutinho*[f], *Julia Arieira*[g,h]

Contributors: Thaís de Carvalho[i],*Camilo Jaramillo Hurtado*[j], *Riikka Kaukonen Lindholm*[k], *Lars Lovold*[l], *Paola Minoia*[i], *Tuija Veintie*[i]

Key Messages

- The peoples of the Amazon have immense wealth in terms of cultural, historical, and ethnic diversity, reflected in their worldviews, knowledge systems, ways of life, and relationships and interdependence with nature. Therefore, within the Amazonian context, intercultural education is an important means of facilitating encounters between diverse knowledge systems.
- Despite the significant knowledge that Indigenous peoples and local communities (IPLCs) possess, there is epistemic violence in the development of contemporary educational and capacity-building processes.
- Constructing participatory intercultural education implies that the parties can not only express their visions but are also open to other perspectives, knowledge systems, and practices. There is an urgent need to exchange experiences so that the strengthening of capacities generates inclusive learning spaces connected to the territory and in dialogue with symbolic languages.
- Creating intercultural education and linguistic policies might be achieved by strengthening local governance and political-administrative autonomy in the development of curricula, creating intercultural education proposals in the urban and rural Amazon; creating bridges between primary, secondary, and tertiary education; and designing participatory curriculum models with the possibility for technological innovation.

Abstract

Intercultural education and capacity building in the Amazon does not recognize, in general, the knowledge, practices, and resources that already exist in the region. Not only has Indigenous and local knowledge (offered by Indigenous peoples, but also by local communities) been systematically ignored, but there is also epistemic violence in the development of educational processes and in capacity-building processes. The Amazon's Indigenous peoples and local communities (IPLCs) have followed various paths in the construction of intercultural education. Challenges and lessons learned from these experiences are

[a]Fundación Tropenbos Colombia, Diagonal 46 No. 20-64, Bogotá, Colombia, sandra.frieri@uexternado.edu.co
[b]University of Brasília Sustainable Development Center (UnB), Darcy Ribeiro Gleba A, Asa Norte, Brasília DF 70297-400, Brazil
[c]National Training Service (SENA) Vaupés, Av. 15 No. 6 176, Mitú, Vaupés, Colombia
[d]Organização Indígena da Bacia do Içana (OIBI), Rua Projetada 70, Centro São Gabriel da Cachoeira AM, Brazil
[e]Pontifical Xavierian University School of Social Sciences, Carrera 7 No. 40 62, Bogotá, Colombia
[f]Amazon Environmental Research Institute (IPAM), Av. Nazaré 669, Centro, Belém PA 66040-145, Brazil
[g] Universidade Federal do Espírito Santo, Instituto de Estudos Climáticos, Av. Fernando Ferrari, 514, Goiabeiras, Vitória, ES, Brazil
[h] Instituto Nacional de Ciência e Tecnologia em Áreas Úmidas (INAU), Universidade Federal de Mato Grosso, R. Quarenta e Nove, 2367, Boa Esperança, Cuiabá, MT, Brazil
[i]School of International Development, University of East Anglia. Norwich Research Park, Norwich NR4 7TJ. England, United Kingdom
[j] Corporacion Selva humeda NGO, Colombia. Carrera 9 No. 71 - 70 Edificio Amazonas, oficina 304 Bogotá Colombia
[k] University of Helsinki, Finland. Yliopistonkatu 4, 00100 Helsinki, Finland
[l] Rainforest Foundation Norway, Norway, Mariboes gate 8, 0183 Oslo

equally varied. This chapter highlights some significant experiences from the region, collected from different authors, that have been developed to build and expand upon participatory and dialogic intercultural education, starting with the problematization of the general educational system and the reflections that this problematizing view leads to. With the cases presented, we reflect not only on the importance of a participatory educational construction for IPLCs, but also that knowledge is a form of communication and political influence that can help in their struggles to guarantee their rights and governance.

Keywords: Amazon, climate change, land-use change, warming, moisture transport, drought, floods, climate models, climate variability, climate trends

32.1 Introduction

The countries of the Amazon have taken various paths to construct intercultural education. The challenges and lessons learned from these experiences are equally varied. This chapter seeks to highlight some significant experiences developed to build and expand upon participatory intercultural education in dialogue, starting with the problematization of the general educational system and the reflections that this problematizing view leads to. Additionally, this chapter contains brief reflections, through the presentation of case studies, on the role of local capacity-building in facing current problems, such as climate change.

According to Walsh (2009, p. 5), "Since its inception, interculturality has meant a struggle in which issues such as cultural identification, law and difference, autonomy and nation-state have been in permanent dispute. It is not surprising that one of the central spaces of this struggle is education, as a political, social and cultural institution: the space for the construction and reproduction of values, attitudes and identities and of the historical-hegemonic power of the State." In this framework, colonial-style educational systems have rarely aligned with diversity, understood as wealth and opportunity; on the contrary, the trend is towards sociocultural homogenization and curricular standardization.

The educational system in the Amazonian context is equally homogenizing. It does not always start from recognizing the diversity of knowledge, practices, and resources present in Amazonian societies. The asymmetry of the educational system can be illustrated by the practice of teaching exclusively in the official language of the nation and the prohibition of other languages, and by the adoption of a standardized model of knowledge transmission (Freire 2005), which promotes national values above the deep knowledge constructed day-to-day through interaction with the territory.

From this perspective, according to Sepúlveda (1996), "interculturality cannot be considered as a simple communication or a transference of cultural content between two cultures, since this communication and transference is complicated by the social asymmetry in the relationship between the two. ... The logic of transference and instruction is quickly assimilated to the logic of power and to symbolic violence. As long as the discourse of one is restricted, there is a manifestation of greater legitimacy of the other, in which a monolingual and monocultural character is evident."

Within this framework, there is a necessity to strengthen intercultural education processes. Indigenous and local knowledge (ILK) is not always valued and treated with the rightful attention it deserves in the formal education systems of the various countries of the Amazon. This failure falls into the aforementioned epistemic violence.

This chapter is made up of seven sections. In the first section, Towards understanding intercultural education and capacity building in the Amazonian context, we introduce concepts of intercultural education and capacity building through a critical lens. In the second section, Diversity in intercultural education and capacity building, we explore the concept of diversity as a possibility and as a condition to enrich intercultural educational processes. In the third section, Recognizing previous knowledge and education contexts to promote diversity, we reflect on the necessity to start with previous knowledge and experiences as a pedagogical resource that allows for the promotion of diversity. In the fourth section, Intercultural education in practice: Significant cases, we present six case studies where intercultural education has been implemented in the diverse contexts and countries of the Amazon. In the fifth section, Emerging reflections and identified needs, we reflect on the presented case studies to harvest lessons that nourish the construction and extension of a participatory intercultural education in the Amazon region. In the sixth section, we present the identified needs and the established recommendations, and finally, in the seventh and last section, we provide final conclusions.

During the public consultation, we received a significant number of new cases and experiences on intercultural education in the Amazon. Contributions have been fully included in the chapter and are found in Annex 32.1 in the format of responses to a questionnaire.

32.2 Towards understanding Intercultural Education (IE) and capacity building in the Amazonian context

Interculturality is usually understood as the construction of spaces for dialogue between different cultures and their equitable interaction to generate shared cultural expressions. This dialogue implies that the parties involved not only have the possibility to express their visions, but also have an openness to other perspectives, types of knowledge, and practices (Van der Hammen *et al.* 2012).

By placing this notion of interculturality in the Amazon, we find a great cultural and linguistic richness that reflects different worldviews and ways of interacting with the natural environment. Unfortunately, not all Amazonian countries have public policies that promote the development of Indigenous languages through public education, and in the cases where there is a “Law of Languages,” as there is in Colombia, there are few mechanisms that generate symmetric bilingual exchanges. (Alarcón 2007) attests that “it is assumed that Spanish should be studied and learned in order to access Western knowledge, science, and technology, without evaluating or analyzing the effects of these integrating processes” (see Chapter 12).

Each one of the nearly 400 distinct groups of Indigenous peoples (Llorente and Sacona 2012; COICA 2019; IACHR 2019) that inhabit the Amazon represent an immense wealth in terms of cultural, historical, and ethnic diversity, reflected in their worldviews, knowledge, ways of life, and particular relationships and interdependence with natural resources. Different communities and populations of the Amazon have coexisted with the territory and nature for many years and have established their lives and existence on notions of balance and interaction with the resources that allow them to survive (Rodríguez and van der Hammen 2000).

Hence, the Amazonian context constitutes a scenario in which the construction of intercultural education becomes an important setting for the encounter of diverse knowledge systems.

According to Walsh (2009), "since the 1980s, interculturality began to be understood in Latin America in relation to the educational policies promoted by indigenous peoples, NGOs and/or the State itself, with intercultural bilingual education (IBE). ... Since the 90s, there has been a new focus on ethnocultural diversity in Latin America, a focus that stems from the legal recognitions and an increasing need to promote positive relationships between different cultural groups, to confront discrimination, racism and exclusion, to make citizens aware of the differences and to train them to work together on the country’s development and on the construction of a just, equitable, egalitarian and plural society.” These normative processes of focusing on ethnic and cultural diversity have been designed and implemented in different ways in the countries that make up the Amazon, and, within them, intercultural education is a contested space that can be interpreted from different socio-political positions.

In Colombia, Indigenous education, initially at the hands of the Catholic Church, has undergone changes based on the social and political struggles carried out by different Indigenous organizations in the 1970s and 1980s, with the support of non-governmental organizations and academics who expressed their concern for an education that defends culture and language. These stances served as input for the 1991 constitutional reform, which led to the ethnoeducation program (Decree 804 of 1995) by the Ministry of National Education (Molina-Betancur 2012).

During the eighties, in Ecuador, the most significant initiatives and proposals for Indigenous education were forged. "In response to the requests of the indigenous peoples of the highlands and the Amazon, the Ecuadorian State decreed, in 1988, the creation of the Indigenous Directorate of Intercultural Bilingual Education (DinBIE) and the Provincial Directorates of Intercultural Bilingual Education. In 1992, the National Congress approved the decentralization of the DinBIE. In 1993, the Bilingual Intercultural Education Model was made official, and in 2000 the educational directorates were organized by nationality, within the framework of the different IBE zone networks" (Vélez 2008).

The 1988 Federal Constitution of Brazil was considered a milestone in the process of recognizing Brazilian sociocultural diversity, thanks to the mobilization of the Indigenous movement, leaders of the black movement, and partners who fought for this recognition, at least in terms of documents (Fialho and Nascimento 2010). Recognition of sociocultural diversity entered educational spaces well before the federal constitution; however, it was only in the 1990s that the construction and implementation of affirmative policies and actions began to promote the recognition of these differences, having within their scope the social inclusion of minority and culturally differentiated groups occupying marginal spaces in society (Fialho and Nascimento 2010). With the presidential decree of 1991, the Ministry of Education of Brazil became responsible for educational policy for Indigenous populations, in collaboration with states and municipalities, the latter being responsible for execution under the guidance of the ministry. In addition to this decree, the Law of Guidelines and Bases of National Education (Law Nº. 9,394 / 96), Opinion No. 14/99 of the National Council of Education, addresses the National Curriculum Guidelines for Indigenous School Education and the National Education Plan (PNE) (Law Nº. 10,172 of 9 January 2001).

The Peruvian Federal Constitution of 1993 recognizes the BIE (Bilingual Intercultural Education) as a fundamental right of Indigenous peoples, following the movement that occurred both in other Amazonian countries with the construction of their new constitutions, as well as international legislation, which increasingly advanced in recognizing the rights of IPLCs. The law on intercultural bilingual education, Law Nº 27,818, requires the Ministry of Education to design a National Intercultural Bilingual Education Plan for all levels and modalities of national education, with the effective participation of Indigenous people (del Pueblo 2011). Also, following the progress of other Amazonian countries, Indigenous participation in universities has grown in the last decade, as have training courses for bilingual teachers (Espinosa 2017).

To explore the future of intercultural education, we will use three perspectives or lenses, as proposed by Walsh (2009), to understand various roles attributed to interculturality. The first is the relational perspective that refers to the contact and exchange between cultures, peoples, practices, and diverse knowledge systems, which occur within conditions of equality or inequality. The second perspective is a functional one that seeks acknowledgment of diversity and cultural differences in order to be included within the system. From this point of view, interculturality is functional to the system and does not include asymmetries or sociocultural inequalities as part of its work. The third perspective, critical interculturality, stems from the acknowledgment that the difference is built under colonial and unequal schemes. From this point of view, interculturality is understood as a process built from the base, and that contrasts with the functional perspective to the extent that its purpose is the transformation of unequal structures.

From the critical interculturality perspective, it can be argued that the physical violence, contempt for, and denial of the various cultural expressions and thinking processes which occurred during complex colonization processes still reside in the memory of the peoples of the Amazon. This epistemic violence is understood by Belausteguigoitia (2001) as "the amendment, the edition, the blur and even the annulment of both the systems of symbolization, subjectivation and representation that the other has of himself, as well as the specific forms of representation and registration."

There are different examples in which it can be concluded that epistemic violence still persists in those spaces in which the inhabitants of the Amazon interact with their neighbors and with different institutions in their daily lives. One of them is the imposition of universal development and learning models for learners in schools with standardized curricula designed under hegemonic models that do not correspond to or dialogue with the knowledge systems, practices, and resources that the different groups build in their lives' domains.

Some examples of epistemic violence are presented in the framework commonly called capacity building. According to UNESCO[m], capacity building takes the form of training, technical assistance, orientation, and preparation through projects adapted to the specific needs of the beneficiary. Some priority issues for capacity building in the Amazon are governance, forest management, implementation of financial mechanisms, project design, climate change, education, and health, among many others. Community appropriation of these topics and processes involves the installation of training devices in which the achieved results and indicators are favored over pedagogical and participatory processes.

Proposals that ignore local practices and knowledge, such as business plans, models for project formulation, and entrepreneurship with pre-established formats, are currently being brought to local communities. The challenge consists of the construction of pedagogical mediations with contextual relevance that favor the shared construction of meaning. For this, it is necessary to start with dialogic encounters that allow the identification and exploration of meaning and definitions that communities have built regarding the issues that training seeks to address.

32.3 Diversity in intercultural education and capacity building

Unfortunately, training frameworks and their daily practices do not always recognize the knowledge and practices that different social groups, such as Indigenous peoples, have built. ILK is rarely included in curricular proposals as an opportunity to strengthen the principle of diversity associated with students' subjective experiences.

There is a diversity of Amazonian inhabitants that are not included in intercultural education policies. This demands a shift from the concept that a particular education is required for certain population groups to a contextualized education that recognizes the uniqueness and diversity of each human being and allows the construction of intrinsic knowledge and connotations according to the experiences of each educational space.

Amazonian diversity, rich in cultural expressions, contributes to the development of roots and identity, which are fundamental principles in the construction of subjectivity mediated by the educational context. If we start from the fact that diversity configures the social reality in the Amazon to the extent that it is pluricultural, then the educational processes must be developed to approach

[m] Taken from: https://es.unesco.org/creativity/fortalecimiento-de-capacidades

diversity as a value and as an educational challenge aimed at expanding and diversifying the pedagogical aspects and didactics framed in the teaching and learning processes that take place in the classrooms.

The concept of diversity in an educational context is occasionally understood from a reductionist lens associated with extraordinary situations in which students deviate from common standards or from the socially constructed figure of a “normal” student. This educational context often embodies a homogenizing educational model that develops strict curricula, identical methodological systems, and standardized systems of evaluation, all with the objective to train people using predetermined knowledge and behavioral patterns.

Thus, the concept of cultural diversity in the classroom refers to dynamic processes of knowledge construction that arise from the trajectories and vital frameworks of persons, and from the interaction between different people in terms of beliefs, values, experiences, cognitive learning styles, and interests, among other aspects. This then refers to the need to work on diversity in the classroom beyond a differential approach, which reduces the complexity of singularity to a category of static and crystallized cultural identity, which does not account for the needs of persons nor allow articulation of their experiences (Frieri and Agudelo 2019).

From this perspective, diversity is not understood as an exclusive exercise within the processes of educational inclusion — often assumed for the care of some population groups through what is known as a differential approach — but rather, it is assumed as a human characteristic, regardless of belonging to an ethnic population or vulnerable population group.

“In this sense, diversity resonates with the concept of singularity according to which each person, by virtue of his or her vital trajectory, constructs the meaning of his or her world, within the framework of social relations in which the connotations of their daily lives are constantly stressed and negotiated. Therefore, there are no persons more diverse than others, but rather, we are all diverse, and it is precisely there where the richness of meeting each other develops " (Frieri and Agudelo 2019).

32.4 Recognizing previous knowledge and education contexts to promote diversity

To recognize and dialogue with students’ previous knowledge and the particularities of their educational contexts requires a permanent ability to characterize context; that is, the development of a lens and integral knowledge of the space and of the people with whom one interacts in that context. Reading context also requires a lens that acknowledges and respects the knowledge that students acquire through their day-to-day lives. In this respect, Cole (2017) states that “people develop cultural tools and cognitive skills associated with the domains of life in which these tools and skills are of central importance.” Similarly, (Bruner 1997) proposes a cultural psychology that situates the emergence and functioning of psychological processes within day-to-day social interactions, and, symbolically, the events that people live out in their daily existence.

From these statements, the existence of one cognitive development model, one in which the subject increments their acquisition and utilization of knowledge as a function of one social and cultural reference framework (in this case, the Western framework constructed in industrialized societies), is questioned. Once questioned, the exploration of and openness towards different forms of knowledge construction becomes fundamental to the educational exercise.

32.5 Intercultural education in practice: Significant cases

The following significant cases from distinct Amazonian contexts provide evidence of the diversity of existing practices in the construction of intercultural education and capacity building. The cases were sent by different authors, invited to participate in the chapter, who live and/or have experience with Indigenous peoples and local communities in the Amazon region. The texts present the contexts in which the initiatives were created and in which important results and reflections were achieved.

32.5.1 Pedagogical and intercultural training in SENA, Vaupés: An approximation to cultural knowledge and practices.

Gloria Amparo Rivera - SENA (Colombia)

In Colombia, there are advancements in national jurisprudence on the recognition of cultural diversity, ancestral knowledge, and collective rights. There are also institutional policies that promote access to training in equal opportunities and attention to diversity. However, national administrations face difficulties in recognizing and incorporating them into national policies and programs.

In this sense, more efforts are needed to systematize, understand, recognize, and scale up successful examples of intercultural higher education. In particular, in the context of technical training, the conviction persists that Western technical and scientific knowledge is superior and must be brought to communities to help them achieve progress.

The National Education Service (SENA, acronym in Spanish) is an institution associated with Colombia's Ministry of Labor that offers technical and technological capacity building. This institution fulfills the national public function of investing in the social and technical development of workers, offering and executing vocational training for incorporating Colombians into productive activities. In fulfilling these functions, it also serves the Indigenous communities of the Colombian Amazon.

In this context, the need to develop a different approach that would address these populations arose, taking into account their cultural, environmental, and territorial features in compliance with Colombia's existing legal framework of recognizing the territorial, social, and cultural rights of ethnic groups.

Practice shows that technical solutions brought to ethnic communities are based on knowledge developed for certain contexts and conditions that involve developed infrastructure and access to capital for considerable investments, and generally neglect the great wealth of resources that Amazonian Indigenous communities living in and depending on the humid tropical forest have.

Based on the experience of SENA-Vaupés since 2013, it is important to consider access to capital as not only specialized human resources but also resources that allow, in a knowledge-based dialogue, the execution of structuring strategies between traditional knowledge and academic knowledge to achieve concrete actions. These include adjustments to curricular designs that link the context, the development of themes on collective rights, the revaluation of Indigenous languages, and the development of local research projects with a strong foundation in ancestral knowledge and practices. This makes it possible to link the cultural, environmental, and diverse potential of the Amazon at the local level.

SENA-Vaupés has strengthened its administrative, formative, and pedagogical capacities in 5 basic steps:

- An agreement with Indigenous communities regarding the necessity for training or other complementary services.
- Strengthening the pedagogical capacities of government employees, instructors, and apprentices through the application of participatory tools to develop characterization and autodiagnostic processes with local communities.
- Creation of projects based on the potential productivity of the environment or culture of the communities or participants, according to their ethnicity and culture.
- Strengthening of cultural knowledge through local research with an intercultural approach.
- Strengthening of the organizational processes of the communities' community organizing, derived from the training and the planification of activities that promote the development of pro-

ductive units, or from the construction of projects for training programs.

Trainings for SENA instructors use participatory, intercultural tools to sensitize them to training processes within a differential context. Pedagogical practices (Figure 1) are strengthened by interactions with Indigenous people, and thus, they generate more successful training that recognizes previous knowledge and ancestral practices. The following results have been obtained:

- Strengthened pedagogical capacities of the SENA instructors.
- Formative planification, where learning objectives are obtained through the implementation of participatory tools and playful activities.
- Learning guides designed with a differential culture focus.
- Linkages between territorial context and the training execution identified and employed.
- Intercultural participatory tools adjusted to the pedagogical context as active didactic tools.
- Linkages with Indigenous instructors.
- Linkages with one Indigenous knowledge holder, strengthening cultural identity in the training processes.
- Research focused on strengthening local and ancestral knowledge.
- SENA staff trained in the use of participatory tools (Figure 32.1).

This training began with a presentation on the pedagogic use of participatory intercultural tools and with strengthening of the didactic capacity of the instructors through the inclusion of characterization and contextualization that linked local knowledge and practices. For three years, this training was available to youth and adults belonging to different communities to generate learning practices that were more dynamic and illustrative. This complementary training paved the path for the SENA-Vaupés office to incorporate capacity-building courses into tourism training a few years later. This training lasted two years, and instructors began to incorporate the cultural, natural, and territorial potential of the Vaupés into their lessons, making the training locally pertinent. The

Figure 32.1 SENA apprentices birdwatching at the national gathering of ornithology (Rivera 2016).

apprentices, alongside the training instructors, associated themselves with the SENNOVA program through the seed fund in Ethno-Ornithology, where they were able to monitor birds in neighboring communities in urban Mitú, to articulate sustainable tourism initiatives based on birdwatching, and to generate important products such as the basic birdwatching guide for the Vaupés region, *Vaupés in plumages, sounds, and colors*. The birds' traditional histories and a digital museum of bird photographs and sounds allowed them to share experiences at multiple national and regional events for avitourism and natural sciences.

This experience resulted in lessons learned associated with a significant practical and knowledge-based potential around forest management, fauna, the flora that must be visualized as a potential basis for scientific research. Additionally, they show the importance of institutional training processes in different Amazonian contexts that allow its members to recognize contextual characteristics of the communities.

32.5.2 Local research to strengthen autonomy and territorial governance

María Clara Van der Hammen and Sandra Frieri (Colombia)

We would like to share the story and analysis of a training experience in territorial governance[n] with the Indigenous communities Koreguaju de Solano, Caquetá, in order to reflect on the possibilities of constructing decolonial practices through dialogue methodologies oriented towards the symbolic articulation between different ways of signifying the world, and the exploration of our own environmental, productive, social, and cultural resources.

The Koreguaju people, with a population of approximately 3,700, belong to the Western Tukano linguistic family. Their ancestral territory is located in the transition corridor between the Andes (the eastern valley of the Andes, contiguous with the Magdalena river) and the Amazon (its eastern plains, in the department of Caquetá, and part of Putumayo, see Figure 32.2).

As part of a project developed by The Nature Conservancy (TNC) and Tropenbos from 2018 to 2019, "Strengthening local governments as a strategy to fight against deforestation in the Caquetá mosaic", we hoped to create spaces for the exchange of experiences in the participatory implementation of territorial management plans elaborated by a previous project with the support of TNC[o], in seven legally-recognized Indigenous territories of the Koreguaju people, and one of the Nasa people, all located in the Peneya River Basin. In this process, there were 2 participants from each of the 8 legally-recognized territories, with the idea that all participants had elements to contribute in the reflections and lessons learned from their respective communities.

The training consisted of combining a series of intra-community activities and inter-community meetings. Collective encounters took place on three occasions, at which, from the beginning, participants aimed to create a space of conversation and dialogue through the presentation of various activities that stimulate participation and connection with the training space.

The participants prioritized, in the implementation of the management plans, the following themes: cultural materials (textiles, ceramics), strengthening of the *chagra*, the territory and its origin stories, traditional Koreguaje food, body paint, and dances associated with rituals. From this point, implementing their own research became the principal mechanism to strengthen their knowledge as a foundation for environmental management actions, whether productive or educational. Local research is a strategy that we have promoted for various decades from the perspective of Tropenbos (https://www.tropenbos.org/where_we_work/colombia), as a way to encourage the transmission of knowledge in communities, from compiling, making it visible, and using it in distinct contexts for the development of productive initiatives, territorial ordering, education exercises, or political negotiation scenarios. This strategy implies the definition of a subject matter, an objective, and a methodology by the local communities, either individually or collectively. It is facilitated through materials (paper goods, cameras, recorders), or money to acquire gasoline or food for meetings. There are no pre-established formats and there is much liberty in the way that these research processes are constructed and used. In some cases, publication of results is facilitated, if this is the

[n] We include within governance as the interactions and accords between governors and the governed, in order to generate opportunities and solve community members' problems, and to construct the institutions and norms necessary to generate change. In the context of Indigenous territory governance, this is associated with aspects such as government autonomy, and the right (and responsibility) to conserve, transmit, and develop their own forms of life and their own culture to future generations.

[o] The objective of these plans is to strengthen governance within legally-recognized Indigenous territories through the reflection on territory, the available resources, and the accordance of a zonification agreement for different uses, and prioritization of actions for sustainable development.

wish of the local researchers and their communities[p].

Through this training, a pedagogical proposal was designed and implemented based on the construction of methodological routes for the strengthening of territorial management. The development of local research served as a departure point for reflection and exploration of diverse forms of constructing and strengthening knowledge associated with culture, which allowed learning to be significant and situated within context. The transformations observed in the participants, understood as unfinalized processes in permanent development, are related to their subjective position in the role of autonomy and leadership. They do not represent just the strengthening of abilities to communicate with others' methodologies and accompany their imple-

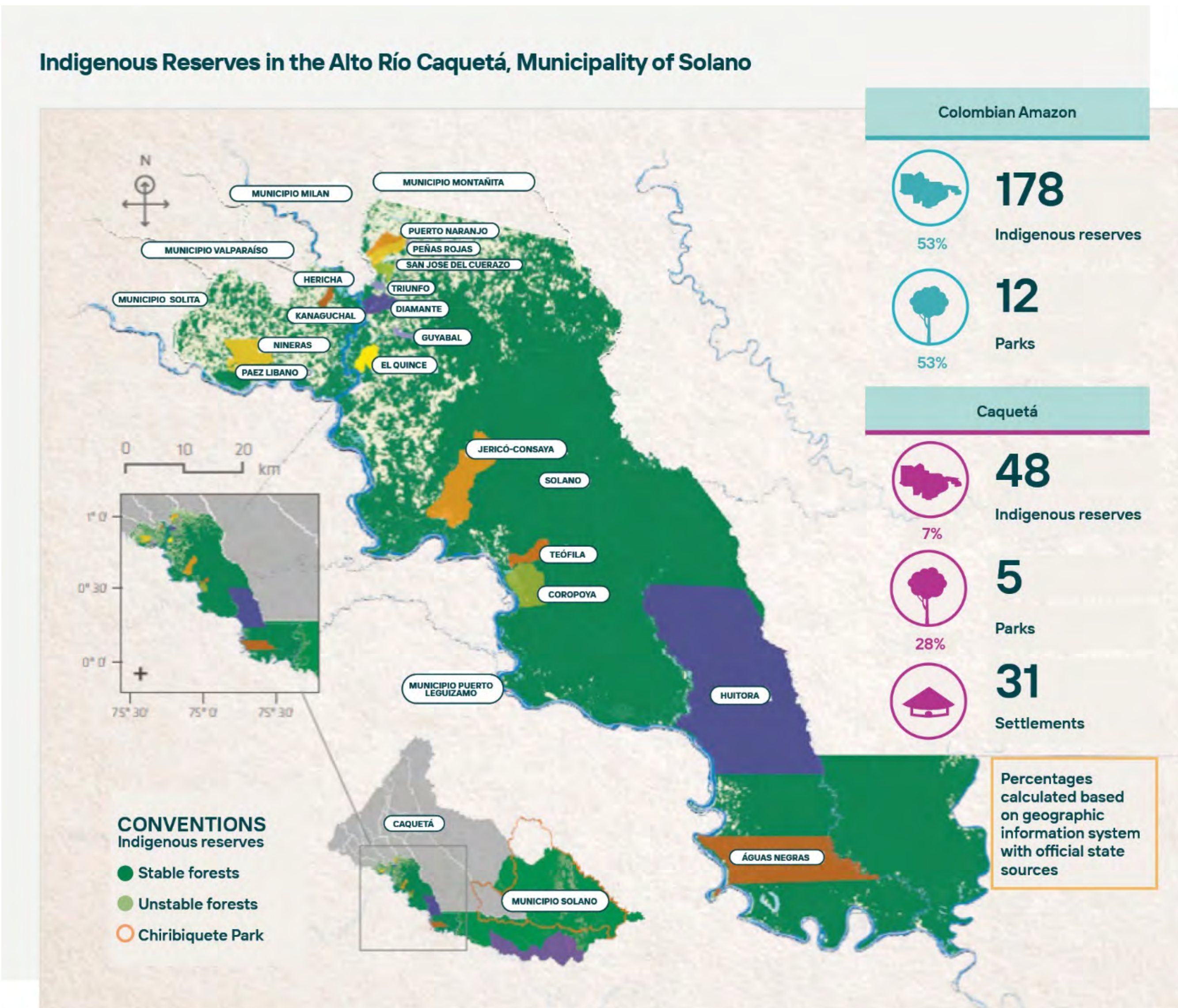


Figure 32.2 Indigenous reserves in Alto Río Caquetá, Municipality of Solano. Source: The Nature Conservancy. Portfolio of projects for the implementation of strategies for the conservation and management of Indigenous territories (Solano-Solita 2018).

[p] For examples, see www.tropenbos.org

mentation and systematization, but also the construction of narrative discourses in relation to pride, cultural identity, and territorial governance in spaces destined for the exchange of experiences and the socialization of the products of the local research. These products become references of externalization and transmission of knowledge processes (Bruner 1997), and they are developed through different strategies of compilation and documentation, such as written text, illustration, photography, and material culture (e.g., baskets, *matafríos*, sifters, ceramics, necklaces).

In this way, positive connection to local knowledge allowed the discovery of identity manifestations in the culture that, as they are recognized, are turned into self-esteem and agency to continue accompanying various participatory processes associated, in this case, with governance and territorial management.

32.5.3. Indigenous intercultural education in the Rio Negro

There is perhaps no other place where there are more intercultural experiences than between the Indigenous and non-Indigenous peoples of the Rio Negro region, where there are 23 different ethnicities, four linguistic families, and 18 languages spoken. In fact, each person, each group of Indigenous people, is already born in the intercultural life environment if we consider that the father and mother are different from each other and they have become one family. In this way, interculturality is lived, many times without knowing that it starts from weddings.

The Indigenous Organization of the Içana Basin (OIBI, acronym in Portuguese), founded in 1992, mobilized the Baniwa and the Koripako, and has served as a tool for the Baniwa to realize their rights, leading the way on many initiatives such as traditional medicine and education, which inspired the unification of spelling of the Baniwa language, the training of teachers, and the elaboration of the Indigenous School Baniwa and Koripako (BIEK Pamáali) (Figure 32.3). In addition, it invested in the production and commercialization of basketry from Arumã and the culinary seasoning Baniwa jiquitaia pepper. The first year of the new millennium was the launch of the Arte Baniwa brand and the inauguration of the BIEK, which impacted municipal policy by creating other elementary schools in Baniwa communities.

Indigenous School Baniwa and Koripako (BIEK Pamáali): Infrastructure, organization, students and teachers, teaching, and languages program

We say that this school is of the Baniwa peoples, because the school was thought of, elaborated, constructed, implemented, and managed by the Baniwa people through their representatives, leaders, and teachers, with the support of partners. This school is recognized by the Educational System of the São Gabriel da Cachoeira Municipality. The Baniwa people began their fight for a school in 1984, reaffirming this fight in 1987 through the Rio Negro Indigenous movement. Between 1992 and 1997, there were meetings and discussions on education where the goal was to seek understanding. In 1998, the school project was proposed in partnership with the Socioenvironmental Institute (ISA, acronym in Portuguese). ISA is a Brazilian NGO, founded in 1994 to propose integrated solutions to social and environmental issues with a central focus on the defense of social and collective goods and rights related to the environment, cultural heritage, and human and peoples' rights) and the Federation of Indigenous Organizations of the Rio Negro (FOIRN), which is the Indigenous organization from the Rio Negro region, founded with the goal to articulate actions in defense of the rights and sustainable development of 750 Indigenous communities in the most preserved region of the Amazon, on the tri-border with Venezuela and Colombia. In 1999, the project was consolidated and the construction of the physical space began. The implementation of this project was made possible by a partnership between the São Gabriel da Cachoeira municipality, the Rio Negro Regional Office of the National Foundation of Indigenous People (FUNAI), and Norwegian secondary school students.

The Baniwa and Koripako School promotes their own learning process utilizing the methodology Teach-by-Research. This methodology has facilitated the teaching and production of intercultural knowledge, whether it is cultural, technical, or scientific, since 2000. The foundation of this process is discussions during meetings where the Baniwas, masters in culture and tradition, teach that the child is born curious. For example, they teach that at birth, the child cries, "where am I?!" We observed that, while the schools of non-Indigenous people valued curiosity only at higher education levels, our school could be different — we could value it from the beginning. Thus, the sum of Indigenous and non-Indigenous cultures that characterize the interculturality of teaching and learning was present at the school.

The school has an infrastructure with a set of houses, including dormitories, classrooms, a library, a cafeteria, a computer lab, a science lab, a native fish fry production lab, fish farming dams, an agroforestry system, a kitchen, an administration office, a flour mill, a tool deposit, and a fuel deposit. The number of houses has increased with the number of students, and the teaching space facilities increase according to the quality of the teaching project. It is a school community, or a community school.

During the school period, the teachers and students live at the school for two months and then return to their communities, where they carry out field research projects. Some classes are theoretical, and some classes are field classes, where stu-

Figure 32.3 Pictures from the Koripako school from the Baniwa indigenous people (A-B) and their educational experiences in management of the land using traditional knowledge (C).

dents practice field methods. The educational process is realized by instituting learning responsibilities. Students are organized in weekly groups with the end goal of developing capacities of organization, planification, accompaniment, and supervision of activities in the school. At the end of each week, there are collective presentations, discussions, and reflections on accountability with their colleagues.

The students in the Indigenous School Baniwa Koripako Pamáali are from the Içana River region and its tributaries: Ayari and Cuiari. They are all Baniwa or Koripako. The objective of the students in the school is to study, valuing their culture and language in order to gain ancestral knowledge and Western knowledge, and create new, creative intercultural knowledge for sustainable environmental and territorial development, always paying attention to and adopting new scientific, technological, and communication practices.

Teachers also embody the role of “parent-educators'', since cohabitation is constant, and on some occasions, students need this sort of accompaniment. In fact, for the Baniwa and the Koripako, there is no separation between educating youth and teaching in school—before a teacher is a school teacher, they must be educated to be an example for the youth during the teaching process, with tools to form their students civically and culturally.

The general themes and objectives of discussions between students and teachers emphasize the constant relationship between the disciplines of the common core and the diversified part (i.e., professional practices). This relationship is reinforced through emphasis on four themes transversal to all disciplines, theoretical or practical, studied in the school or in the communities of origin of the students: Politics, rights, and Indigenous movements; Baniwa Ethics; Politics and Education for Health; and Sustainable Development. The Pedagogical Political Project, oriented towards training through participatory action research, is focused on the problems and potentials of the *buen vivir* (welfare) of the Indigenous communities in the Içana Basin, and has been responsible for the formation of the new social capital responsible for the socioenvironmental management of the demarcated Indigenous territory, whose extent occupied by the Baniwa/Koripako comprises an area of ~3,487,792 ha and houses a population of 6,200 people in 93 sites and communities.

The Baniwa Koripako Pamáali School, although its curriculum is developed from its own practice, is also part of a curriculum common to non-Indigenous schools, so that it is possible for students to finish their studies in other schools.

Research is carried out in the native language, since the Indigenous narrative respects the context and true significance of tradition, and in this way, it is more likely that the work returns to the community. The School is multilingual, with five languages: three Indigenous and two national languages. The Baniwa language is one of the co-official Indigenous languages of the municipality of São Gabriel da Cachoeira and, along with the Koripako language, is widely spoken throughout this region. The school also uses the general language, or Nhengatu, which is spoken by many ethnic groups in the Rio Negro region, the Spanish language because of the neighboring countries Colombia and Venezuela, and Portuguese, the national language of Brazil.

All disciplines have the objective to facilitate fluency in the Portuguese language, verbal and written, as this is important for comparison, confrontation, and mutual comprehension between cultures, opening doors for intercultural dialogue. Learning Baniwa and Koripako is also important and structured, as this is fundamental to prevent these languages from becoming extinct like other Indigenous languages. Additionally, by teaching the phonetics, phonology, morphology, and grammar of our local languages, others can have access to study and write in them. Written Baniwa and its study can be studied by Indigenous peoples and by other people interested in learning them. It is the same with Nhengatu and Spanish.

Results

- 86 students graduated from the BIEK between 2000 and 2011 (from 148 total students). They came from 35 different communities in the Basin, and from 13 different clans from the main Baniwa and Koripako fraternities (the Dzawinai, Walipere, Hohoodene, Kapitiminanai, and Komadaminanai Indigenous groups).
- 32 indigenous teachers have taught at the BIEK. They also received training as they worked.
- Graduated BIEK students went on to become teachers (39%), researchers (14%), community leaders (3%), public health officers (1%), military personnel (8%), secondary students in other Içana communities (21%), students in urban secondary schools (9%), and non-student wives (6%).
- 24 Baniwa/Koripako women were educated between 2000 and 2011 (28% of the total). They are now teachers (6), researchers (2), secondary students in other Içana communities (7), students in urban secondary schools (3), and non-student wives (6).
- Capacity at the BIEK: The ideal number of people studying and working is between 80 and 100. For example, 7 teachers, 1 cook, and 1 general service provider serve 78 primary and secondary school students. The freshman class that entered elementary school in March 2012 had, for the first time, more girls (7) than boys (5).
- Thematic activities for general public education: BIEK also regularly receives 5–20 students per cycle that are teachers, public health officials, and leaders from other schools or communities in the Basin for workshops, courses, and research activities that focus on themes such as computer science, environmental management (forest and fisheries), aquaculture, Indigenous health, rights, project and organization management, and economic entrepreneurship.
- BIEK maintains an average of 40–50 primary school students, and 20–30 secondary school students, with a total of 70–80 students.

BIEK-educated students will help with the construction of policies and autonomy in the communities, and will fight for their educational rights. Today, in the Içana Basin there are 25 complete schools, something that would have been thought impossible 18 years ago.

The decision of the Baniwa and Koripako peoples to create their own school had a positive impact on various public initiatives. For example, it led to the creation of a Master's Degree and intercultural certifications as a proposal from the Institute for Indigenous Knowledge and Research of the Rio Negro.

The collective school education project of the Baniwa and Koripako peoples is thriving. In the future, the Baniwa and Koripako peoples hope to create a higher-education institution.

32.5.4 Balcanes Farm at the Universidad de la Amazonia and its role in Intercultural Knowledge Mediation (MIC)

Bernardo Herrera H. (Amazônia Colombiana - Universidad de la Amazonía)

The current case study about the role of intercultural mediation at the university is inspired by two gaps found by the most recent report on post-conflict Colombia by the Kroc Institute, firstly the absence of consideration for gender, and secondly the exclusion of Indigenous peoples. Having a gender focus and including Indigenous peoples are both crucial for the consolidation and adhesion to the peace accords. Both motivations coincide with prior academic research on the role of intercultural knowledge mediation and field research to characterize this role (Herrera 2020a).

In this context, the Balcanes case proposes the possibility of an alliance between a university (Universidad de la Amazonía, Florencia, Caquetá, Colombia) and an Indigenous organization (Agrosolidaria) to lead a knowledge dialogue about the *chagra* (agricultural plot). This is an example where the university became an Intercultural Mediator of Knowledge (MIC, acronym in Spanish) with Indigenous women farmers. The knowledge dialogue highlighted and strengthened the role of Indigenous women in securing food security and sovereignty. Women in the Amazon are increasingly assuming the role of household heads and leaders of agricultural production. This case study invites us to reclaim the role of universities and Indigenous or community organizations in recognizing the Indigenous *chagra* and mediating productive knowledge dialogues.

Between 2019 and 2020, multi-situated ethnographies were carried out with the populations and riverine territories of the Guaviare and Caguán, and in the Orteguaza Basin, where the current case study is situated. Together, these rivers contribute 40% of the Amazon's flow, and, of the 400,000 ha deforested each year in Colombian territory, more than half of it is in the upper basin of the Amazonian region.

The "farmer-professor", as Orlando Alzate is known, is a farmer in the high Caguán, where he went after being displaced from the Río Pato valley for claiming the land as his right. In 2000, when he was already 60 years old, he decided to study agroecological engineering, a study offered by the Universidad de la Amazonía. There, he was put in charge of the Balcanes Farm. Orlando began a dialogue process with ancestral knowledge, which bore fruit after two decades of lessons learned in the community.[q]

Twenty years later, a generation of youth lead the Balcanes Farm. Graduates of the agroecology program coordinate the Balcanes Farmer School of Amazonian Knowledge. The coordinator of the farm, along with their partner, work with the farming community, and cultivate their own plot together, growing various non-timber species. They describe this as the "thesis of the knowledge dialogue with Indigenous communities. ... [It] is an understanding of their worldview and beliefs in their nature, and, in this spirituality, understanding the magic of the plant, which is also the magic of the knowledge ... from this tradition through ... their... plants, their medicine. ... One asks, how is it that they've achieved this through time, and how is it that they can continue with food security and sovereignty, while taking care of our Amazon?" (Herrera 2020).

In this context, the Balcanes case proposes the possibility of an alliance between the university and Indigenous communities for a dialogue of knowledge oriented towards the *chagra*. Could university farms mediate and resist biopiracy in the commercialization of seeds and plants developed from the accumulated knowledge of farmers and Indigenous communities?

We propose an affirmative answer to the question, taking the experience of the Universidad de la Amazonía as an example of an Intercultural Mediator of Knowledge (MIC, acronym in Spanish), as long as women farmers are included. This requirement is important for their role in sovereignty vigilance and food security in the Amazonian context. Not only are women often the head of the family, their contributions towards the agricultural production of the region is rising. This case study invites us to reclaim the role of the university, as well as those of community organizations, such as Agrosolidaria, in order to recognize the Indigenous *chagra,* and to mediate in a knowledge dialogue.

Intercultural Mediation (MIC) is a resistance against hegemony and a route to food security and sovereignty. It is important to interculturally mediate the search for governance over nature, including the role of care by women. This happens, for example, in the recognition of the leadership of women leaders in Nükak villages in the Colombian Guaviare.

In this context, it is important to recognize the river as a vehicle for the exploitation of timber within the forest. Through the river it is possible to connect timber markets to roads and urban centers. Within this commercial process there is an absence of recognition of ancestral knowledge, which can be transformed by intercultural mediation in an anti-

[q] Learn more through a video available at https://www.youtube.com/watch?v=ujHh0-Jhodw&t=823s.

hegemonic perspective.

Recognition of the role of the river is a mandatory step; before the river was used to exploit timber, it linked its upper course to the lower course and, like a highway system, links the market with urban centers. In the river's commercial flows, one can observe the lack of recognition of ancestral knowledge. In this flow, we can also understand it as a form of intercultural mediation in an anti-hegemonic perspective.

The experience of Agrosolidaria grounds the academic discourse and encourages the shared construction of meanings. The discourse “has lowered the sky to the ground”, as a leader from the Association of Economic Solidarity shared. In order to not exclude women, maintenance fees were lowered from 10,000 to 5,000 (from USD$3, dues were cut in half). Lowering the cost allows more access to women because they are paid less in the labor market.

These food security processes extend beyond the familial scale. In terms of empowerment and governance, reclaiming the territory has to happen at a national and multilocal scale. In the construction of this food sovereignty, there is co-production (Miller and Wyborn 2020) of knowledge. At a distance from the Western anthropocentrism, one has to contemplate the rights of nature, and the principle of intellectual property, recognizing at a constitutional level the knowledge of ‘native’ communities in the *buen vivir,* which originates from Amazonian peoples.

32.5.5 Climate change as a strengthening theme and struggle for the Indigenous peoples of the Amazon

Fernanda Bortolotto and Paulo Moutinho (Brazilian Amazon)

This case study presents how leaders of Indigenous peoples in the Brazilian Amazon incorporate climate change into their agenda and the fight for their territories. By strengthening the capacities of Indigenous and non-Indigenous peoples, Indigenous peoples are constructing their own narratives, based on their knowledge and life experiences, to incorporate into national climate policies. As an example, the National Plan of Adaptation in Brazil acknowledged Indigenous and local knowledge as an important tool for adaptation. Also, after multiple workshops with Indigenous peoples and local communities (IPLCs), the plan included the results of their local studies about climate impacts on their lives.

Indigenous peoples possess multiple types of knowledge related to climate because of their dependency on natural resources, in particular knowledge on seasonality for harvesting and rituals. Armed with this knowledge, they know what to wait for and the anomalies that exist (Turner and Clifton 2009). Their deep understanding of variability allows them to easily distinguish between normal delays and the impact of climate change.

In the last 20 years, Indigenous leaders and representatives to the Coordination of Indigenous Organizations of the Brazilian Amazon (COIAB, acronym in Portuguese) have participated in meetings and discussions about climate change, organized and promoted by NGO partners such as the Amazon Environmental Research Institute (IPAM), the Socioenvironmental Institute (ISA), Greenpeace, The Nature Conservancy (TNC), and the Education Institute of Brazil (IEB). In these meetings, Indigenous leaders are introduced to technical concepts about climate change, concepts established by non-Indigenous researchers who rarely consider the perspective of Indigenous peoples in the elaboration of their studies or concepts.

Indigenous leaders present comprehensive reflections about climate change, framing it as an axis of fight for territorial rights. According to Sonia Guajajara[r] (Bortolotto 2020), “Today, you can’t just fight for climate change without considering Indigenous peoples or the role of Indigenous territories.

[r] Information collected via interview with Sonia Guajajara, March 12th, 2020.

For all this, to confront climate change, you have to make necessary the fight for territorial rights, human rights, and specific rights."

This comprehension is notable because the most recent demands that Indigenous leaders have brought to the UNFCCC, between 2016 and 2018, presented in an institutional space[s], consider national climate policies and strategies. Territorial demarcation, strengthening Indigenous organizations, and environmental and territorial management are the principal issues in their demands (Bortolotto 2020). By strengthening their territorial fight, they also reaffirm their links and connections with nature, connecting the climate agenda with the Indigenous movement's other priorities.

The development of Indigenous peoples' demands illustrates how the production of ideas and concepts by actors, on the one hand, and the institutionalization of agreements and practices, on the other, are mutually constitutive (den Besten *et al.* 2014). The combination of Indigenous claims with themes on the world agenda, such as climate change, is a political strategy capable of guaranteeing the recognition or appreciation of ethnicity and Indigenous organizations and peoples as legitimate political subjects that can influence decision-making processes beyond their territories (Doolittle 2010; Bortolotto 2020).

Capacity-building processes on climate change, alongside the leadership of Brazilian Amazonian Indigenous peoples, resulted in the creation of an institutional space in 2016, within the National Foundation of Indigenous Peoples (FUNAI). FUNAI is the official Indigenous organization in Brazil responsible for the protection of Indigenous rights and assuring ethnic plurality.

From this space, Indigenous representatives from their community organizations influenced public policy on climate change elaborated in the 2016-2018 period. Both in policies of mitigation, such as the REDD+ National Strategy and the Nationally Determined Contributions (NDC), and policies of adaptation, such as the National Plan for Adaptation, the greatest demand from Indigenous organizations was the guarantee of their territories, and the completion of all due demarcation processes.

32.6 Emerging reflections and identified needs

The cases presented in this chapter provide evidence of the diversity of contexts in which intercultural education can be constructed. These include intercultural education in community schools that offer elementary education, in schools that offer secondary and technical education, in institutions that offer post-secondary technical education, and in universities. At the same time, there are experiences of capacity building with Indigenous peoples in the framework of climate change projects and the construction of governance and leadership processes.

Some cases demonstrate interesting alternatives to the increasing integration of the Indigenous population and other Amazonian actors into national economies under standardized programs, and poor recognition of local economic systems. In contrast, there are experiences, such as the one carried out in the SENA-Vaupés in Colombia, which depart from Indigenous and local knowledge to design and implement projects on alternative sustainable products. This case shows an important post-secondary training experience in which a governmental institution includes an intercultural education policy. At the same time, the intercultural mediation and the dialogue of knowledges between Indigenous and community members around agricultural practices and the important role of women in the construction of these knowledges, are part of the experience of the Balcanes Farm in the Universidad de la Amazonia in Colombia

[s] In 2016, the Climate Change Technical Office of the National Environmental and Territorial Management Policy for Indigenous Lands was established. This space was intended to strengthen Indigenous participation in national climate policies that were under preparation and implementation in Brazil, in addition to strengthening the discussion on the topic among Indigenous leaders.

When higher education involves Indigenous peoples, it is worth noting affirmative actions have been in elaboration in Brazil over the past 15 years, such as the quota law in Brazil, which incentivized the matriculation of Indigenous students in universities (Dal Bó 2018). The law, Nº 12,711 from 29 of August 2012, titled the Quota Law, stipulates that all federal universities must use a percentage of their scholarships for black and Indigenous students. After the law was passed, an estimated 8,000 Indigenous students from multiple peoples matriculated in higher education, in contrast to 1,300 students in 2004 (Bergamaschi *et al.* 2018). Considering the sociocultural diversity in Brazil, the law was a great achievement for Indigenous peoples and other social movements, who had been fighting for the democratization of higher education for all Brazilians since the Federal Constitution of 1988 (Baniwa 2013).

The presence of Indigenous peoples in universities offers possibilities for self-reflection on the university's pedagogical practices and its social role. However, there are still major challenges to be faced, such as the permanence of Indigenous peoples in the university, which depends on financial resources, the financing of research in their communities, and complementation of the quota system with projects and programs that enable support of Indigenous scholars throughout their training (Baniwa 2013).

The case study presented by André Baniwa, from the upper Rio Negro (Brazil), allows the appreciation of the construction of an intercultural education project in Indigenous schools in a context where there is great diversity of Indigenous peoples. The possibility to construct their own curriculum, with a strong emphasis on language, strengthens autonomy in this context. Additionally, the importance of local research, focused on Indigenous and local knowledge, is a way to strengthen the Baniwa peoples. The local research produced on sustainability projects in the region is also a way of communicating with the non-Indigenous public, funding agencies, and other partners, fitting not only as an educational model but also as a strategy for organizational strengthening and expansion of relationships (Dal Bó 2018). From this process of construction, fight, and experience, Indigenous autonomy is important in the political and economic realm, as well as with partners and supporters.

Cases that demonstrate important experiences in capacity building associated with climate change in Brazil, and the strengthening of leadership and governance in Colombia, put into evidence the significant lessons and the individual and collective transformations of those who participate in these spaces when training is a dialogical approach that allows connection with the previous knowledge of the participants.

The diversity of cases allows us to conclude that when curricula and training plans are in dialogue with day-to-day experiences, the sociocultural context, and Indigenous and local knowledge, subjectivity takes its place in institutions and new forms of relation with each other and the territory are created, giving way to the construction of interculturality.

There are several needs to strengthen intercultural education. One is the valuation of Indigenous languages in intercultural education policies. Another is the strengthening of Indigenous organizations and local communities, towards the support of intercultural education processes, as well as education councils, differentiating them at the local, regional, and national scale. Intersectoral policies that connect educational processes developed at multiple institutions and for multiple population groups with cultural, economic, and productive sectors are also required. Funding is needed for intercultural education processes in the medium- and long-term. Another gap is the use of participatory curricular models and methodologies that allow those who design and implement intercultural education and capacity building to create spaces for dialogic learning, connected with the territory, with the possibility for technological innovation, and the creation of intercultural education proposals in the urban Amazon to facilitate continuity and higher education.

Given these needs, a first recommendation is the construction of platforms for knowledge dialogues and decision-making that involves the participation of actors (local, private, public, and academic) that could come together to think through education and pedagogy in the Amazon. Platforms oriented towards knowledge dialogues can be nourished with different methodological proposals developed by local communities that allow the recuperation of knowledge and experiences, which can be put to service for educational projects and capacity building.

Local investigation is part of the recognition that communities are particular universes, with their own histories and accumulated knowledge of the surroundings, constructed through their interactions. To promote local research, it is necessary to generate ideas on the use of the content developed through the research and the possibilities to strengthen ongoing local projects with the information compiled. Also it is important to identify the knowledge holders with whom the local research will be carried out (Van der Hammen *et al.* 2012).

The systematization is oriented towards identification of emergent learning from the experiences of teachers and students. This type of systematization establishes the reconstruction and recovery of experiences for the purpose of critically interpreting occurrences. As well as obtaining these, the lessons learned and understandings will allow the improvement of practices; to propose the possibility of learning from the implemented actions implies a potential to transform and share them (Jara 2012). The systematization supposes an active linkage of people that develops intercultural education and that the protagonists of the experience give meaning. The systematization of important experiences of intercultural education and capacity-building, as described in this text, make possible the design of different curricular models in which daily educational experience can strengthen official proposals. In the same way, the design of training-the-trainer workshops, and the development of pedagogical guides and materials based on significant experiences from the perspectives of teachers and appendices are important opportunities to include diversity and strengthen the formative processes.

Although teachers and technicians who tend to lead training processes have a solid disciplinary training, under this proposal, it is necessary for them to have tools that allow an integrative and interdisciplinary view of reality, including social, political, economic, cultural, and environmental aspects.

Exploring distinct pedagogic and didactic proposals allow the trainer the elements to attempt new forms of teaching, the ability to reflect on their own practice and transform it, the ability to value differences as enriching opportunities, the ability to get to know the students, diversify, and adapt the curriculum, and the ability to propose learning experience pertinent to the context. All these elements are configured in possibilities for education within diversity, assuming that these differences are opportunities to create culturally pertinent and relevant education.

32.7 Conclusion

The Indigenous and local knowledge of Amazonian populations is rarely recognized in formal education processes and capacity building. Such knowledge is not only systematically ignored, but there is also epistemic violence. Through the standardization of curricula and courses required of Indigenous peoples, local, traditional, and rural communities can lead to the erasure and even extinction of a diversity of knowledge that is fundamental for the permanence and survival of these peoples.

With this problem in mind, in this chapter we present important case studies by different authors from different countries, representing regional and sociocultural diversity in the Amazon Basin. We hope that these cases contribute to a greater reflection about the incorporation of Indigenous and local knowledge in the construction of locally-appropriate education, and that the recognition of the knowledge held by Amazonian peoples is a potent tool for the maintenance of sociobiodiversity in the region.

However, we recognize that there have been a number of successful experiences in the region involving the specificities of Indigenous peoples and local communities that we were not able to include in this chapter. The inclusion of more representative cases from the region was a barrier in the elaboration of the document. Some workshops were held with stakeholders from the region, in addition to direct invitations for authors to contribute cases that presented models for implementing intercultural education in local contexts. Unfortunately, we did not have the expected response within the given time for writing the chapter. One of the recommendations for the next version of this chapter would be the inclusion of more authors representing IPLCs, who can bring more reflections on the implementation of appropriate educational practices.

There is also a gap in the academic literature on the state of the art of intercultural education in the countries of the Amazon Basin and the involvement of IPLCs, both in the development of specific programs and policies as well as in monitoring the implementation of such actions. Further research, as well as the contribution of more authors, mainly Indigenous and from local communities, would be necessary to represent the challenges of implementing intercultural education and strengthening adequate capacities for Amazonian diversity.

32.8 Recommendations

In general, intercultural education and capacity building in the Amazon does not recognize the knowledge, practices, and resources that already exist in the region. Not only has Indigenous and local knowledge (offered by Indigenous people, but also by local communities) been systematically ignored, but there is also an epistemic violence in the development of educational and capacity-building processes. To address these inequalities and in accordance with the discussions brought by the cases and experiences presented in this chapter, we highlight some recommendations:

- Create participatory intercultural education and linguistic policies that recognize the experiences and efforts that communities and institutions have been developing in these fields. Likewise, guarantee the participatory implementation of these public policies.
- Create intercultural education proposals in the urban Amazon and bridges that facilitate continuity to reach higher education.
- Create and strengthen interdisciplinary and participatory Amazon research involving IPLCs that can help us understand and confront the changes that the Amazon is going through.
- Create spaces for intergenerational transmission of traditional and contemporary knowledge to strengthen local, technical, and scientific capacities to face the regional problems of the Amazon.
- Strengthen local governance and political-administrative autonomy for the development of education programs and the implementation of intercultural education and linguistic policies.
- Design participatory curricular models and pedagogical support material based on ILK, with the possibility for technological innovation, to avoid standardized curricula and highlight the culture and knowledge in the local context.
- Create spaces for the exchange of experiences in intercultural education in the Amazon and experiences from mainstream society to expand knowledge about the region, its knowledge, practices, threats, and diversity.

32.9 References

Alarcón WD. 2007. Bilingüismo indígena en Colombia. *GIST--Education Learn Res J*: 24–38.

Baniwa G. 2013. A Lei das Cotas e os Povos Indígenas: mais um desafio para a diversidade e para a inclusão social - Geledéshttps://www.geledes.org.br/a-lei-das-cotas-e-os-povos-indigenas-mais-um-desafio-para-a-diversidade/. Viewed 28 Apr 2021.

Belausteguigoitia M. 2001. Descarados y deslenguadas: el cuerpo y la lengua india en los umbrales de la nación. *Debate Fem* **24**: 230–52.

Bergamaschi M, Doebber M, and Brito P. 2018. Estudantes indígenas em universidades brasileiras: um estudo das políticas de acesso e permanênciahttp://rbep.inep.gov.br/ojs3/index.php/rbep/issue/view/274/14. Viewed 17 Nov 2020.

Besten JW den, Arts B, and Verkooijen P. 2014. The evolution of REDD+: An analysis of discursive-institutional dynamics. *Environ Sci Policy* **35**: 40–8.

Bortolotto F. 2020. Participação indígena brasileira na Convenção do Clima: a construção da agenda climática como pauta de luta. : 189.

Bruner J. 1997. Pedagogía popular. In: La educación, Puerta de la cultura. Visor Dis., SA Madrid.

COICA. 2019. Coordination of Indigenous Organizations in the Amazon Basin (COICA). Agenda Indígena Amazônica Viewed

Cole M. 2017. Psicología cultural: una disciplina del pasado y del futuro. Ediciones Morata.

Dal Bó TL. 2018. A presença de estudantes indígenas nas universidades: entre ações afirmativas e composições de modos de conhecer.

Doolittle A. 2010. The politics of indigeneity: Indigenous strategies for inclusion in climate change negotiations. *Conserv Soc* **8**: 256.

Espinosa O. 2017. La Educación Superior Intercultural en la Amazonía Peruana: Balance y desafíos. *Anthropologica* **35**: 99–122.

Fialho V and Nascimento R. 2010. Antropologia, Educação e Estado Pluricultural: : notas sobre o sistema educacional brasileiro frente à pluralidade cultural. *O Público e o Priv* **16**.

Freire P. 2005. Pedagogía del oprimido. México: Siglo XXI Editores S.A.

Frieri Gilchrist S and Marcela Agudelo Ortiz D. 2019. Capítulo V. Memoria, saberes e intersubjetividades en el aula: prácticas culturales para la restauración de vínculos sociales. In: Cátedra Unesco. Derechos humanos y violencia: Gobierno y gobernanza. Universidad externado de Colombia.

Hammen M Van der, Frieri S, Zamora NC, and Navarrete MP. 2012. Herramientas para la formación en contextos interculturales (SN de Aprendizaje, Ed). Bogotá, Colombia: Tropenbos Internacional Colombia, Tropenbos Internacional Colombia. Nuffic-NPT.

Herrera B. 2011. La Interculturalidad en la Mediación del Conocimiento. In: Castro-Gómez S, Saldarriaga O (Eds). Revisado a partir de ensayo presentado en el doctorado en Ciencias Sociales y Humanas Pontificia Universidad Javeriana - Arqueo. doctorado en Ciencias Sociales y Humanas Arqueo Genealogía de la Colombianidad.

Herrera B. 2020. Mediación Universitaria para la Solidaridad en Comunidades Morales. Por el derecho de la naturaleza en territorios de paz. In: Álvarez J, Zabala H, Salgado O, *et al.* (Eds). Hechos y emprendimientos cooperativos de transformación. Actas del XI Encuentro de Investigadores Latinoamericanos en Cooperativismo.

IACHR. 2019. Situation of Human Rights of Indigenous and Tribal Peoples of the Pan-Amazon region. Inter-American Commission on Human Rights and Organization of American States.

Jara O. 2012. Sistematización de experiencias, investigación y evaluación: aproximaciones desde tres ángulos. *Rev Int Investig en Educ Glob y para el Desarro*: 56–70.

Llorente JC and Sacona U. 2012. Investigación aplicada a la educación intercultural bilingüe: Algunas reflexiones epistemológicas.

Miller CA and Wyborn C. 2020. Co-production in global sustainability: Histories and theories. *Environ Sci Policy* **113**: 88–95.

Molina-Betancur CM. 2012. La autonomía educativa indígena en Colombia. *Vniversitas* **61**: 261–92.

Plan de Salvaguarda del Pueblo Koreguaje. 2014. Asociación de Autoridades Tradicionales del Consejo Regional Indígena del Orteguaza Medio Caquetá - CRIOMC Viewed

Pueblo PD del. 2011. Aportes para una Política Nacional de Educación Intercultural Bilingüe a favor de los pueblos indígenas del Perúhttp://repositorio.minedu.gob.pe/bitstream/handle/20.500.12799/854/489. Aportes para una Política Nacional de Educación Intercultural Bilingüe a favor de los pueblos indígenas del Perú.pdf?sequence=1&isAllowed=y. Viewed 11 Apr 2021.

Rodríguez C and Hammen M van der. 2000. Biodiversidad y manejo sustentable del bosque tropical por los indígenas Yukuna y Matapí de la Amazonia colombiana. In: El Vuelo de la Serpiente. Desarrollo sostenible en la América prehispánica. Siglo del hombre editores.

Sepúlveda G. 1996. Interculturalidad y construcción del conocimiento. *Educ e Intercult en los Andes y la Amaz*: 93–104.

Turner NJ and Clifton H. 2009. “It’s so different today”: Climate change and indigenous lifeways in British Columbia, Canada. *Glob Environ Chang* **19**: 180–90.

Vélez C. 2008. Trayectoria de la educación intercultural en Ecuador. *Rev Educ y Pedagog*: 103–12.

Walsh C. 2009. Interculturalidad crítica y educación intercultural. *Inst Int Integr del Conv Andrés Bello*: 9–11.

Annex 32.1 Cases & Experiences in Intercultural Education in the Amazon

Objective 4+: Eco-cultural pluralism in quality education in the Ecuadorian Amazon

Contributor: Paola Minoia

Organization: University of Helsinki

Location of the initiative or project: Pastaza Province, Ecuador

Description of the project or experience: Access to scholastic and university education is seen as the main means to empower marginalized groups and enhance sustainable development in the Global South. In Ecuador, the intercultural bilingual education program that affirmed the fundamental importance of the integration of diverse local languages, knowledge, and pedagogical practices in education was established as early as 1993 and later modified based on the philosophy centered on the community, the ecological balances, and the culturally sensitive philosophy of *sumak kawsay* or *buen vivir*. The program is still only partially implemented, and therefore education generally follows homogenized standards and does not include specific cultural realities, placing Indigenous nations in an unfavorable position compared with the majority of the mestizo population.

The project expands upon Sustainable Development Goal 4 (Quality Education), through the promotion of cultural diversities, which include ecological cultures, and also the recognition of Indigenous pedagogies, which should be included in the programs to reinforce educational quality in the Ecuadorian Amazon. The inclusion of ecological aspects is important for Amazonian Indigenous groups who have strong connections to the land and natural resources, currently threatened by illegal logging, oil extraction, hydroelectric projects, and climate change. Defending eco-cultural diversity means protecting both the Amazon's delicate environment and the survival of Indigenous peoples threatened by poverty and cultural disappearance.

The 4-year project (2018–2022) was funded by the Academy of Finland and the Ministry of Foreign Affairs of Finland (Develop Program n.318665) and was carried out in close collaboration with Ecuadorian researchers from the Amazon State University who have established connections with Indigenous communities.

Target Communities and Number of People Reached: Indigenous Communities of Pastaza

Goals: The project is divided into four objectives aimed at

- Evaluating the spatial-temporal access of Indigenous youth to upper secondary schools, universities, and workplaces.
- Understanding how the principles of eco-cultural diversity and *sumak kawsay* are respected and realized in education and university programs.
- Studying the transition of Indigenous students to tertiary education or working life from upper secondary schools.
- Analyzing bilingual intercultural education policies and establishing a research network on Indigenous and intercultural education.

All objectives pay attention to gender-specific challenges in intercultural education. The data consists of educational materials and documents, interviews, observations, photographs, videos, drawings, and GPS points collected and analyzed using mainly qualitative and participatory approaches.

Strategies and Challenges: Collaboration with universities and Indigenous organizations.

Key Results: Interculturality in universities, improved access to higher education for all.

Intercultural bilingual education in the transition from primary to secondary school

Contributor: Thaís de Carvalho

Organization: School of International Development, University of East Anglia

Location of the initiative or project: Calleria, Ucayali, Peru

Description of the project or experience: Participant observation for 7 months in the region of Ucayali, with immersion in a rural intercultural bilingual school in Peruvian Amazon, and focus groups with Shipibo school evaluators.

Target Communities and Number of People. The village has a total of 73 children at primary school, but the case study discusses the reality of intercultural education in rural schools for the Shipibo–Konibo people (which has a population of at least 45,000).

Goals: Identify challenges and contradictions of the intercultural education system.

Strategies and Challenges: Reflect on how to incorporate participatory values and Freirean pedagogy in hierarchical settings.

Key Results: There is a paradox in the aspirations of parents and Indigenous organizations. This is not well incorporated by the State, and there is a lack of reflection on the racism of State institutions that regulate intercultural education

Education and Indigenous territorial struggles: A study of the Sapara people's experiences with the education system in the Ecuadorian Amazon

Contributor: Riikka Kaukonen Lindholm

Organization: University of Helsinki

Location of the initiative or project: Pastaza Province, Ecuador

Description of the project or experience: I conducted ethnographic research collaborating with members of the Sapara nation in the Ecuadorian Amazon. The research investigated the experience of the Sapara people with intercultural bilingual education in Ecuador and its relation to their territorial rights and struggle for self-determination. This investigation was part a Master's thesis and book chapter (in production). Future research concerning Indigenous self-determination with the Sapara is ongoing as part of a doctoral dissertation.

Target Communities and Number of People Reached: 27 people in four Sapara communities (Llanchamacocha, Cuyacocha, Jandia Yacu, and Atatakuinja), university students from Universidad Estatal Amazonica, and teachers in IBE Amauta Ñampi (Puyo).

Goals: Identify which educational practices strengthen political emancipation and territorial self-determination of Indigenous peoples and understand the challenges faced by Indigenous groups in identifying and implementing such practices.

Strategies and Challenges: Ethnographic research (semi-structured interviews and participant observation); securing access to the field and limited time available for research in remote communities.

Key Results: Indigenous political institutions can be supported when the education system respects Indigenous culture. Cultivating Indigenous knowledge in the education system can strengthen and revitalize cultural expressions of the Sapara, including decision-making practices that can contribute to political emancipation and territorial self-determination. Furthermore, Saparas emphasized how their holistic and relational world-view, which includes values and a vision for themselves, should be conveyed to future generations. In this project, education is indispensable. However, Indigenous knowledges should be integrated in a manner that does not fragment, decontextualize, or severe links to community and relations, where knowledge is traditionally shared, since relationships and holism are innate qualities of knowledge, without which it loses its meaning. Furthermore, a vision that Saparas hold for education would support different epistemologies as complementary.

Hence, Saparas appreciate learning aspects of Western science that they perceive as valuable assets in the globalized reality that they face. In this sense, education can further serve as a cultural broker that prepares Saparas with tools and knowledge to understand and navigate both worlds. However, the most important way in which education could strengthen Indigenous territorial self-determination and political emancipation, advocated furiously by many interviewees, is how it should be organized locally, in a respectful manner, and within the context of local particularities. Only in this manner can groups such as the Sapara truly transfer knowledge to their children, avoid the problems caused by migration, and reduce the monetary demands that come from intensified contacts with the capitalist mode of production. In practice, this means that the Sapara people themselves would have a greater autonomy and would meaningfully participate in the development of educational content. This also requires respect for the historical and geographical contexts that the Sapara people face. Historically, Saparas have been great in number, but tens of thousands were decimated as a result of disease, assimilation to other Indigenous communities, enslavement, and forced migration. Today, the Sapara people number around 200-300 individuals, the smallest Indigenous nationality in Ecuador. This poses considerable challenges for education and cultural revitalization, which depends on respect for their special condition. This also requires that education not be centralized, as this enables the Sapara people to practice their livelihoods and students to learn also outside of the school together with their community.

Revival and regeneration of indigenous knowledge in intercultural bilingual teacher education: a study in the Ecuadorian Amazon

Contributor: Tuija Veintie

Organization: University of Helsinki

Location of the initiative or project: Pastaza Province, Ecuador

Description of the project or experience: Doctoral research on Intercultural Bilingual Teacher Education. Empirical study conducted in the Pastaza Province in Ecuadorian Amazon in 2007–2010.

Target Communities and Number of People Reached: Target communities: 3 (Kichwa, Shuar, and Achuar)

Goals: This study examined how Indigenous knowledge is recognized and incorporated into a teacher education program targeted at Indigenous Shuar, Achuar, and Kichwa students.

Strategies and Challenges: The field study was conducted in one intercultural bilingual teacher education institute with students who self-identify as Kichwa, Shuar, or Achuar, and educators representing Indigenous and non-Indigenous people. This qualitative interpretive study involved ethnographic fieldwork with observation in the classroom and outside school hours, interviews with students and teachers, and participatory photography and photo-elicitation. Coding and interpretive analysis of the data was conducted through inductive and theory-oriented readings. During the time conducting this research project, the Ecuadorian government initiated a major reform in education, causing instability in the activities of the intercultural bilingual teacher education institute.

Key Results: This study showed that the Shuar, Achuar, and Kichwa teacher education students conceptualized knowledge and learning primarily through their everyday domestic life, and schooling seemed to play a secondary role. Both the students and the educators were concerned about the amount of theory-oriented education in schools, and believed that learning through observation and practice, hands-on activities, and manipulative educational materials was culturally pertinent for Indigenous students. Interview data show that many of the Kichwa, Shuar, and non-Indigenous teacher educators in the IBTE institute were committed to reasserting and supporting the revival of

Indigenous knowledge. Furthermore, these educators perceived Indigenous knowledge as an important resource in terms of confirming Indigenous identity. The interviews and observations showed that the educators promoted Indigenous knowledge in their instruction, particularly by bringing students' knowledge into the classroom, using culturally-relevant instruction methods, and connecting with the Indigenous community. The non-Indigenous educators sought Indigenous knowledge from books, the Indigenous community, and the students, and used instructional methods, such as hands-on activities and group work that they considered culturally pertinent to the students. The Kichwa and Shuar educators drew on their own life experiences, knowledge, and Indigenous oral tradition in their classroom instruction. The observation data also showed some examples of educators furthering dialogue between Indigenous and non-Indigenous knowledge, which offered opportunities to regenerate Indigenous knowledge by creating knowledge in between diverse epistemologies. The study indicates that more effort is needed to develop instructional practices that would better reflect Indigenous epistemologies. The Shuar, Kichwa, and non-Indigenous educators, and the Shuar, Achuar, and Kichwa students discussed, for instance, the relevance of connecting instruction with the Indigenous community and learning through exploration. However, based on observations, connections with the community or learning through exploration were not among the common instructional practices at the teacher education institute. The data showed that the incorporation of Indigenous knowledge into instruction forms a challenge for educators because of the lack of adequate educational materials, insufficient or lacking initial or in-service education related to Indigenous students and intercultural bilingual education (IBE), and the lack of educators' understanding of epistemological diversity and Indigenous knowledge. Furthermore, IBE teacher educators' cultural, linguistic, and educational backgrounds vary, as does their commitment to IBE and their preparedness and willingness to break with the epistemological hierarchy and strive for epistemological justice by promoting Indigenous and alternative knowledge, ways of thinking, and instruction practices.

Contribution to the recovery of the know-ledge of the *chagra* of Indigenous communities of the department of Vaupés as a model of intervention in the production of self-consumption

Contributor: Camilo Jaramillo Hurtado

Organization: Corporación Selva Húmeda NGO

Location of the initiative or project: Township of Yabarate. Papunahua and Pacoa, Department of Vaupés.

Description of the project or experience: Provide temporary support to families through resources and interventions to meet the minimum conditions for quality of life that are not covered in conventional assistance programs; develop a framework of co-responsibility with the users so that the families overcome their situation of vulnerability and poverty.

Target Communities and Number of People Reached: Approximately 1,044 families.

Goals: Contribute to the recovery of traditional knowledge, and strengthening and diversification of the *chagra* of Indigenous communities as a model of intervention in the production of self-consumption.

Strategies and Challenges: The project is adapted from the precepts of the conventional lines of the Food Safety net (Red de Seguridad Anlimentaria [ReSA]) and the social prosperity philosophy, which is aimed at improving food production processes through the strengthening of traditional agroecological practices, local seed saving/production, and promoting healthy eating habits.

Key results: 1. Socialization, consultation with traditional authorities. 2. Develop a model of intervention in food and nutritional security, according to the dynamics of the territory and cultural characteristics of the Indigenous population. Four routes were established and include the following topics: a. Socialization of the project and diagnosis of communities. b. Preparation of organic fertilizers and seedbeds. c. Strengthening and/or preparation of the farm and delivery of supplies. d. Healthy habits and lifestyles. 3. Contribute to the strengthening of 1,044 *chagras* of the prioritized communities in order to improve the conditions of access to food. 4. Deliver the prototype of inputs adapted to the geographical and environmental conditions of the area. 5. Promote clean food production methods among participating families (i.e. quality, safety, and nutritional value). 6. Generate skills and capacities focused on collective work, preservation of the culture and food heritage of the community, and good eating habits in families. 7. Strengthen the social and community fabric around ancestral values and traditions, autonomy, and the rights of the community.

Bilingual, culturally adapted education for Indigenous peoples in Brazil.

Contributor: Lars Lovold

Organization: Rainforest Foundation Norway

Location of the initiative or project: Bilingual, culturally adapted education for Indigenous peoples in Brazil.

Description of the project or experiences: Training of Indigenous teachers, development of curriculums, production and printing of education materials in Indigenous languages and Portuguese.

Target Communities and number of people Reached: Many Indigenous communities during the 1990s and early 2000s.

Goals: Obtain the right to culturally-differentiated and socially-relevant education for Indigenous peoples in Brazil.

Strategies and challenges: Develop a series of pilot experiences, gradually obtaining financial and political support from the relevant municipalities and states; having a continuous dialogue with the Ministry of Education to get formal approval for curricula, education materials, etc.

Key results: Indigenous teachers trained, education materials developed, public support for Indigenous schools obtained, the right to culturally differentiated education obtained.

Amazon Assessment Report 2021

Chapter 33

Connecting and sharing diverse knowledge systems to support sustainable pathways in the Amazon

Manifestação dos Povos Indígenas, Largo São Sebastião, Manaus, Brazil (Foto: Alberto César Araújo/Amazônia Real)

INDEX

GRAPHICAL ABSTRACT 2

KEY MESSAGES 3

ABSTRACT 3

33.1 INTRODUCTION 4

33.2 INSPIRING EXPERIENCES AND PATHWAYS 9

33.2.1 Illustrative experiences of collegial contributions 12
33.2.2 Illustrative experiences of Co-Created Projects 13
33.2.3 Illustrative experiences of Collaborative Projects 13

33.3 DISCUSSION AND RECOMMENDATIONS 14

33.4 CONCLUSIONS 16

33.5 RECOMMENDATIONS 16

33.6 REFERENCES 17

ANNEX 33.1. PROPOSAL SUMMARY OF A CONCEPTUAL FRAMEWORK FOR THE FUTURE OF THE AMAZON 19

ANNEX 33.2. ILLUSTRATIVE EXPERIENCES 23

Graphical Abstract

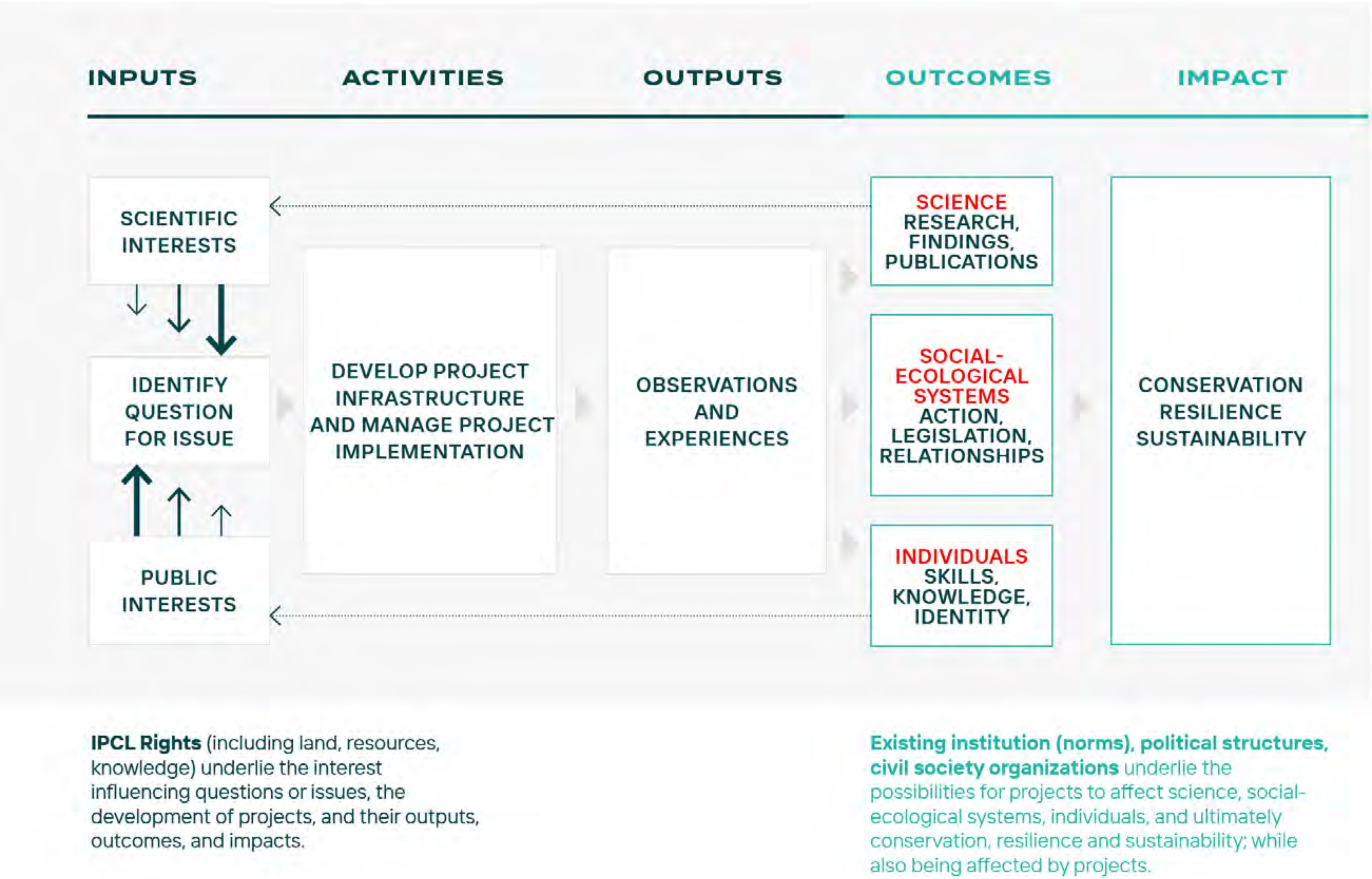


Figure 33.A Graphical Abstract

Connecting and Sharing Diverse Knowledge Towards Sustainable Pathways in The Amazon

Mariana Varese[*a,b], Carlos Rodríguez*[*c], Natalia Piland[d,a,b], Simone Athayde[d], Diana Alvira Reyes[e], Carolina Doria[f,g,b], Juan Alvaro Echeverri[h], Christopher Jarrett[e], Uldarico Matapí[i], Ney José Brito Maciel[j], Visnu Posada[k], Oscar Romualdo Román-Jitdutjaaño[l], Leonardo Tello[m], and Luis Angel Trujillo[n]*

Key Messages

- Indigenous and local knowledge (ILK) has been critical for conservation and sustainable development across the Amazon. However, ILK systems, best practices and lessons that can inspire sustainable pathways for the Amazon are often unrecognized and overlooked in decision and policy-making.
- Many inspiring solutions to the problem of unequal knowledge production, sharing, and articulation in decision-making exist at the local scale; these solutions must be scaled up while combined with policy recommendations and guidelines stemming from global experiences.
- To most effectively align different social actors in knowledge production, sharing, and informed decision-making, a critical first condition involves recognizing and guaranteeing fundamental rights of people and nature, and recognizing ILK. Then, it is urgent to strengthen knowledge dialogues and to enact open and collaborative knowledge principles, through policies, agreements and protocols for each step of the knowledge sharing process. These should be the product of multi-stakeholder collaboration, defined in specific terms and adapted to diverse contexts, objectives and needs.
- The proposed efforts should build on progress made by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) partnerships, emblematic platforms, and should involve the leadership of the IPLCs, grassroots organizations, academia, civil society, and national science councils or ministries.

Abstract

Although Indigenous and Local Knowledge (ILK) held by Indigenous peoples and local communities (IPLC) has been critical in conservation and sustainable development efforts across the Amazon, there is lack of appropriate recognition and internalization of lessons offered, hindering just and inclusive knowledge production, and participatory and effective decision-making at local, national, and international scales. Many inspiring solutions to the problem of inequitable knowledge production, sharing, and inclusion in

[a] Wildlife Conservation Society, Avenida Roosevelt 6360, Miraflores, Lima, Peru, mvarese@wcs.org
[b] Citizen Science for the Amazon Network, AV. Roosevelt 6360, Miraflores, Lima, Peru
[c] Tropenbos Colombia, Diagonal 46 No. 20-64, Bogotá, Colombia, carlosrodriguez@tropenboscol.com
[d] Florida International University, 11200 SW 8th Street, Miami FL 33199, USA
[e] Field Museum, 1400 S Lake Shore Dr, Chicago IL 60605, USA
[f] Universidade de Rondônia, Av. Presidente Dutra 2965, Centro, 76801-974 Porto Velho RO, Brazil
[g] Ação Ecologica Guaporé – Ecoporé, Rua Rafael Vaz E Silva, 3335, Liberdade, Porto Velho 76.803-847
[h] Universidad Nacional de Colombia, Instituto Amazónico de Investigaciones (IMANI), Sede Amazonia, Kilometro 2 Via Tarapacá, Leticia, Amazonas, Colombia
[i] Elder of Upichía People, Colombia
[j] Instituto Internacional de Educação do Brasil, Center for Latin American Studies, University of Florida, USA
[k] Universidad EAN, Carrera 11 No. 78-47, Bogotá, Colombia
[l] Resguardo Indígena Andoque de Aduche, Colombia
[m] Radio Ucamara, Nauta, Loreto, Peru
[n] Local connoisseur and fisherman, Puerto Carreño Vichada, Colombia

decision-making exist across the Amazon. In this chapter, we use the conceptual framework of public participation in scientific research and an appreciative inquiry approach to review and synthesize a range of illustrative initiatives in the Amazon which align scientific (academic), technical, and Indigenous and local knowledge systems in conservation and development initiatives. We also consider recent policy recommendations and guidelines by local and global professional associations as well as civil society organizations. In order to most effectively align different social actors in knowledge production, sharing, and informed decision-making, a critical first condition involves recognizing and guaranteeing fundamental rights of people and nature, and recognizing ILK. To achieve this goal, it is urgent to strengthen knowledge dialogues, and to enact open and collaborative knowledge principles, through policies, agreements and protocols for each step of the knowledge sharing process. These should be the product of multi-stakeholder collaboration, defined in specific terms and adapted to diverse contexts, objectives and needs. Based on this, we recommend interventions at various scales, including strengthening and scaling up intercultural knowledge dialogue platforms; promoting structural change and training of the institutions that currently make decisions, in order to enable IPLC engagement and strengthen public participation in decision-making; ensuring transparency and accountability of the process; and creating and strengthening intercultural, multi-stakeholder networks to devise collaborative solutions for reconciling the conservation of Amazon ecosystems and the well-being of its peoples.

Keywords: knowledge dialogues, intercultural platforms, public engagement in science, public participation in scientific research, open science, collaborative networks, epistemic justice, Indigenous knowledge, local knowledge, citizen science.

33.1 Introduction

Different worldviews and knowledge systems coexist in the Amazon, often in contrasting conceptualizations of well-being and sustainable development (Arruda and Arruda 2015; Inoue and Moreira 2016; Jacobi *et al.* 2017). Despite the enormous diversity of knowledge systems connected to Amazon cultural and biological diversity (Chapter 10), there are limited investigations into how these systems generate, transmit, use knowledge, and, above all, how they might be better integrated into decision-making processes at different scales toward just and sustainable futures (Bradshaw and Borchers 2000; Cash *et al.* 2003; Lahsen and Nobre 2007; Jacobi *et al.* 2017). Lahsen and Nobre (2007) highlight that this research gap is particularly important in less developed countries, which host a significant part of the world's cultural and biological diversity. Strengthening the dialogue between different knowledge systems, as well as public participation in knowledge production and use, is of prime importance to improve conservation and sustainable development, but these approaches have not yet become a priority for public policies (Congretel and Pinton 2020).

Over the past 30 years, different stakeholders, from civil society to government agencies, have increasingly acknowledged the contribution of Indigenous and Local Knowledge (ILK) to Amazon conservation and sustainable development. It is evident that the number of documented contributions of ILK to decision-making in Amazonian countries has increased year to year. A search in the full collection of the Web of Science[o] resulted in over 14,000 peer-reviewed articles between 1951 and March 2021, in a clearly increasing trend, with over 1,400 articles published in 2020 (see also McElwee et al. 2020 for an extensive global review of ILK in large-scale ecological assessments). However, an Amazon-wide specific review on this topic is still necessary. For example, less than 15 papers of the 214 papers published since 2018 under the Web of Sci-ence

[o] For this exploratory search, we used the following combination of key words: ((TOPIC: knowledge* AND dialogue*) OR (TOPIC: dialogo* de saberes) AND (TOPIC: amazon*)), and a time frame from 1951 to 2021.

category “Environmental Sciences and Ecology” actually pertained to the Amazon, despite the addition of the “Topic” term “amazon*”.

ILK is based on long-term, place-based co-evolution with ecosystems and biodiversity, and as such, has the potential to facilitate dialogue between IPLC, and academia and government (Whyte 2013), as well as to contribute to Amazon sustainable development (Athayde et al. 2016; Jacobi et al. 2017; Lahsen and Nobre 2007). Similarly, there is a vast experience of participatory science and monitoring in Latin America and specifically in Amazonian countries, applied to natural resource and territorial management initiatives, in defense of human and environmental rights, and in advancing scientific research (Conrad and Hilchey 2011; Lopes et al. 2021; Piland et al. 2020). Also, the importance of increased public engagement in science and collaborative knowledge production and sharing has received global recognition and attention, not only for their value to science, but also for their contribution to democratizing knowledge and societies and for fostering the implementation of effective solutions to socio-environmental, economic and health problems, climate change, and contributing to the United Nations Sustainable Development Goals (Shirk et al. 2012; McKinley et al. 2017; Fritz et al. 2019; Benyei et al. 2020; Fraisl et al. 2020; Cooper et al. 2017;).

However, except for a few successful experiences, there is much need for improving knowledge generation and sharing between multiple stakeholders with diverse interests and levels of power to inform solution pathways toward sustainable development (SD) in the Amazon, i.e., inform and engage in management and policy decisions at multiple scales. Often, knowledge exists in silos, failing to be effectively aligned or connected across the region, across disciplines, and across stakeholders (Pretty et al. 2009; Nobre et al. 2016). On the one hand, knowledge seems to be insufficient, or sufficient but not readily accessible for decision-makers (from community managers to government agencies). On the other hand, ILK and participatory science and monitoring (under many designations) have a long tradition of producing valuable knowledge, but this knowledge has not been sufficiently acknowledged and internalized by others in power, including academia, government, and civil society organizations (see for instance Cooper et al. 2014; and DuBay et al. 2020 in Box 33.1). Therefore, in part because of this lack of acknowledgment and also because of colonial legacies and epistemic violence tied to institutions, policies, and politics (see Chapter 31, Liboiron 2021, David-Chavez and Gavin 2018), valuable knowledge to inform just and sustainable pathways for the Amazon remains mostly local in reach and poorly integrated into decision-making across Amazonian countries (Jacobi et al. 2017; Doria et al. 2018; Athayde et al. 2019; Matuk et al. 2020; McElwee et al. 2020). Moreover, in some instances, Indigenous and local communities’ knowledge is being lost owing to transculturation, inefficient inter-generational transmission, and other external pressures. Changes in climate phenomena and land use have exposed many communities to situations that are new or for which their knowledge may seem not applicable (Benyei et al. 2020; see also Chapter 31 for a case study in which Indigenous peoples contributed to climate change policies).

The Amazon Basin also presents a context of inequalities in terms of communication and power relations among diverse stakeholders (Newig and Moss 2017), and a history in which science and research policies and investments in the Amazon have been insufficient and inadequate (Lahsen and Nobre 2007; Nobre *et al.* 2016; Athayde *et al.* 2019 and others) to address the challenges of a dynamic system threatened by several drivers and processes (see Parts I and II for further detail on historical processes and the state of the Amazon; Chapter 31 for a discussion on the impacts on education; Dorninger *et al.* 2021 for an analysis of resource inequity). As a result, public engagement in decision and policymaking, and especially engagement of Indigenous and local peoples in policymaking, is still limited and inequitable in the Amazon. Although significant progress has been made in this regard in various Indigenous territories and community lands (see Chapter 31), barriers for

Box 33.1 Who Gets to Name Species?
Natalia Piland

The Amazon Basin is home to 10–30% of the world's species (Yale 2020, Mongabay 2020). From a western science perspective, we can provide this statistic, used in various calls to action and conservation (for example, WWF 2013, Rusu 2019), thanks to the process of species description. Species descriptions "elevate" the observation of an individual bird to the abstraction of a species (DuBay, Palmer, and Piland 2020), and the statistics resulting from information on species are used to justify decisions made regarding conservation action/inaction (for some methodologies, Guisan et al. 2013, Nicholson et al. 2013). At the same time, these species descriptions have broader implications: they confer authority and professional opportunities on the authors of these species descriptions (for an example in inequity in citation practices, see Meneghini et al. 2008), and honor Western individuals by using their given and/or family names as honorifics in the Linnean taxonomy. While seemingly innocuous, strict authorship practices mean that the individuals that reap the benefits of the species descriptions may not be the original holders of knowledge or cohabitants of the area the species is from, and honoring Western individuals may actively exclude or signify the exclusion of racialized, gendered, or ethnicized groups.

In a recent paper, we found that even though 95% of bird species described in the last 70 years were from the global South (with three countries in the Amazon basin: Perú, Brazil, and Colombia), names of birds disproportionately honored individuals from the global North (DuBay, Palmer, and Piland 2020). Additionally, the majority of primary authors of these eponyms were from the global North. The implications of local author inclusion were clear—if there was at least one local author (i.e, an author that was from the country the bird was from), it was 62% more likely that the bird would be named after someone local. However, this research did not capture what we anecdotally know: while these species descriptions are often written by researchers based outside of the country, they would not be possible without the indigenous and local knowledge that those authors obtained through conversation or hiring of local labor. Therefore, species descriptions and the surrounding research practice have tangibly been implicated in the erasure of indigenous and local knowledge while becoming by-lines in researchers' curriculum vitaes and further honoring non-local scientists.

In the United States, we have seen a movement, led primarily by younger birders, to change birds' names, at least the common names. For example, McCown's Longspur was named after John P. McCown, who shot the type specimen and sent it to an ornithologist friend to describe and ten years later joined the Confederate army during the United States Civil War, which fought to defend slavery (Elbein 2020). The group Bird Names for Birds organized a successful formal petition with 180 signatories to deliver to the American Ornithological Society's North American Classification Committee to change the common name to one that is descriptive of the species (Roach 2020). The naming of a bird after a Confederate general signifies the long history of exclusion and violence of the birdwatching and environmental communities in the United States, and changing the name signifies commitment to addressing and repairing the harm done by these communities. It is worth noting that this change came after the widespread protests against police brutality following the murder of George Floyd—As recently as 2018, the AOS's NACC had denied a request to change the name (Roach 2020, Elbein 2020).

Beyond changing the names of species that honor racist individuals, initiatives to address the epistemic inequalities in our fields should go hand-in-hand with a reflection of power dynamics and dialogues that facilitate a respectful exchange of ideas and knowledge. Considerations in these initiatives can include questions such as: Is authorship a valuable signifier of authority, and, if so, are all the people who hold and create knowledge, even when not in the form of writing, acknowledged (whether this is through citation or authorship)? Is collective authorship an option in the places where you publish? Is participation informed, voluntary, and consensual? Who leads the research and what power dynamics are implicated? Are there differential expectations for different groups (for example, the expectation of communicating in English gives an implicit advantage to those who are from English-speaking countries, countries who invest in wide-range English education, or from socio-economic backgrounds that allow access to English education from an early age)? Can those expectations be changed (for example, scholarship and degree-granting programs to be offered in local and indigenous languages)? Is the indigenous and local knowledge being valued as is or is such knowledge valued only when it conforms to Western values? Who is the research and the species descriptor for?

participation in decision and policy making are common, especially outside these jurisdictions and at larger scales. It is still necessary to further understand and make visible these barriers, especially systemic and structural ones, such as systemic racism. Also, the larger the scale, the greater the inequalities in terms of the possibility of citizens, communities, and grassroots organizations to effectively engage in generating, sharing, and using knowledge for decision and policy making (for a review on size and political participation, see McDonnell 2020).

At the root of the problem in scaling up successful approaches for knowledge dialogues and public participation in decision-making, as well as in knowledge generation and sharing, lie power relations rooted in formal institutions and regulations that determine whose knowledge is more valid or valuable, who is the expert and who is not (Athayde et al. 2019; Arruda and Arruda 2015; Barthel and Banzhaf 2016; Jacobi *et al.* 2017;; Chambers 1995).

To further promote the sharing and alignment of diverse knowledges for sustainable development, McElwee *et al.* 2020's review recommends the following:

"The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment (GA) demonstrated the importance of Indigenous peoples and local communities (IPLC) to global biodiversity conservation and ecosystem management. (...) Successfully bringing ILK into assessment processes and policy arenas requires a deliberate framework and approach from the start that facilitates recognition of different knowledge systems, identifies questions relevant at various scales, mobilizes funding and recognizes time required and engages networks of stakeholders with diverse worldviews." (p. 1667)

In addition, we propose that stakeholders involved in this process ask critical questions, such as: For whom, by whom, and for what purpose should science investments and policies be promoted in the Amazon? What conditions are needed for a thriving science and knowledge-sharing environment in the Amazon? How can barriers be broken for genuine knowledge dialogue that recognizes, credits and legitimizes ILK and other non-academic contributions (Tress et al. 2005), and recognizes IPLCs as political subjects for informing decisions and policies? What conditions are needed for effective and equitable knowledge sharing among multiple stakeholders and across multiple scales in the Amazon? What can be done to ensure that knowledge about the Amazon is effectively accessible and disseminated in the region and among Amazon peoples, rather than remaining accessible only to those who can afford access to peer-reviewed journals, publications in English, or university libraries? Answers to these questions are context-based and the product of negotiation between involved stakeholders; ideally through a transparent, just, and equitable process.

Specific challenges in this process involve, for instance, ensuring appropriate credit to IPLCs and non-academic contributions to knowledge generation and sharing, and avoiding co-opting, technifying, or de-contextualizing ILK (Athayde *et al.* 2017; 2016) in research, conservation, and development initiatives. Also, although there is global consensus that science is a common good (UNESCO 2017), the principle of 'situated open access' needs to be carefully implemented in contexts such as the Amazon, where Indigenous Peoples, and, in many instances, local communities, are right holders, rather than stakeholders. This concept applies Donna Haraway's notion of "situated knowledge" to the practices of open access—understanding the context, power relations, and structures that relate the humans and institutions that would produce and/or use knowledge would allow open access to be implemented in a just way (Haraway 1988; OCSDNet 2015).

As with open access, public participation by other stakeholders (e.g., students, volunteers, activists, urban grassroots organizations, professional associations) in the process of knowledge generation, sharing, and use still has a long way to go. The negotiation process to determine what knowledge is 'better' than others needs to take place on more equal terms than what is currently in place. The UNESCO-led process to build a global consensus and adoption of a UNESCO Recommendation on Open Science, scheduled for September 2021, discusses several of these challenges (UNESCO 2020, Wehn et al. 2020) and the comments received by civil society organizations (especially by the Global Citizen Science Partnership and the Open Science Community of Practice) provide effective guidance on how to address these challenges.

It is important to emphasize that at the community and local scales, significant progress has been made in addressing these problems. Solution pathways to generating and sharing knowledge for informing decisions and policies towards sustainable development in the Amazon should build on these experiences, and also on on Indigenous and other civil society organizations' needs, interests, and political agendas. For instance, the Declaration of Belém+30 that calls for, among others, recognition and respect for the right of self-determination of IPLCs and all other human rights, free prior informed consent, benefit sharing from research, prevention of inadequate access or misuse of—and access to—raw data, documentation, information, and artifacts obtained through research in their territories or sacred areas (International Society of Ethnobiology 2018). Also, global and regional professional associations and Indigenous researchers have recently issued best practices, policy recommendations, and ethical considerations for projects that involve IPLCs and public participation (see Bowser *et al.* 2020; Carroll *et al.* 2021; Liboiron 2021). There is still much to do to systematize and disseminate this growing body of knowledge and experience, to harvest lessons and best practices, and to foster their application and adoption in multiple contexts and at larger scales. Platforms for knowledge dialogue between academia and government agencies are also missing or incipient (McElwee *et al.* 2020). Legal frameworks in Amazonian countries continue to present weaknesses in terms of recognizing intellectual property rights tied to Indigenous and local contexts, which increases barriers to establishing inclusive, ethical, and transparent dialogue platforms between them, academia, and government agencies. Similarly, legislation on open science and public engagement in science is still not adequate in several countries of the region. Third, private and public investments in science, research, and technology in the Amazon are still limited and insufficient, more so if these are for and by Amazon peoples (Nobre *et al.* 2016).

The authors of this chapter use an appreciative inquiry approach (Preskill and Catsambas 2006) to build from success stories, best practices, and lessons learned, acknowledging and expanding them, with an Amazon constituency that fosters a knowledge-based sustainable development paradigm for the Amazon. The chapter is informed by a stakeholder engagement process that identified core elements of a future Amazon vision (see Annex 1; also Chapter 25 for a proposed Living Amazon vision). These core elements are built on two foundational pillars: (1) acknowledgment and respect of fundamental human rights and the rights of nature, specifically the right to land, and (2) acknowledgment and incorporation of ILK and IPLCs in decision-making about the future of the Amazon (see also Preskill and Catsambas 2006, p.1). Based on these pillars, the other four core elements of a vision for the Amazon include the incorporation of ILK in natural resource management public policies and planning; strengthening territorial governance (see also Chapter 31); the conservation of the Amazon's forest and aquatic ecosystems and the services they provide, such as climate regulation, rainfall regimes, and biodiversity maintenance (Chapter 27); and addressing forest and aquatic ecosystems destruction and degradation (Chapters 19–21) and other threats to biodiversity. Therefore, we propose a path forward that starts by reviewing, systematizing, and disseminating lessons learned and best practices, and then applying these learnings to create relevant, just, and effective platforms, ethical procedures, policies, and legal frameworks, and to creatively address the lack of financial and technical resources for connecting diverse ways of knowledge generation and sharing in the Amazon, while calling for greater investments in these initiatives.

Specifically, this chapter takes a first step forward in this process by presenting a set of illustrative experiences of collaborative research that provide concrete examples of knowledge dialogues, public engagement in science, and knowledge sharing for decision-making (Section 2). These experiences showcase how knowledge dialogues and public engagement in science have worked, and how ILK has contributed to sustainability, and provide lessons and guidance for solution pathways in both knowledge dialogues (in Spanish, "diálogo de saberes") and decision-making. These cases were compiled from the experience of the authors of this chapter and those that we were able to synthesize as part of the Science Panel for the Amazon. They are not meant to be exhaustive, and, in fact, we believe that a first recommendation should be the conduction of a comprehensive review of ILK and public (non-academic) knowledge contributions in the Amazon.

Building on these experiences, we then provide a set of recommendations on pathways to move forward (Section 3). The recommendations outlined in this chapter focus on the creation of conditions that promote just and inclusive dialogue between knowledge systems, including: investment in infrastructure (research and technological); creation of normative frameworks for data sharing and ownership, participation, and collaboration; strengthening and expanding intercultural platforms with a long-term commitment; structural change that allows for transparency and effective public participation in decision-making at various spatial scales; and intercultural training for decision-makers in various organizations.

33.2 Inspiring experiences and pathways

Existing experiences and programs offer success stories and lessons learned on generating, connecting, and sharing knowledge to inform and guide decisions and policies. For each case, we attempted to provide information about the process, context, and actors, as well as insights to consider when creating other experiences.

We propose a framework to guide the reflection on public participation (including Indigenous peoples and local communities, civil society organizations and individuals) in knowledge generation and sharing. This framework builds on Shirk et al. (2012, p. 29), who proposes the following:

"Projects must balance inputs from scientific interests and public interests, but each project negotiates that balance differently (as represented by input arrows of different sizes). Projects also exhibit different outcomes for science, individuals (researchers or volunteers), and social–ecological systems, which may relate to the particular balance of inputs. Note feedback arrows: certain outcomes may reinforce certain interests—and therefore particular design emphases—as initiatives evolve over time. Quality public participation depends upon sufficient attention to public interests in the input stage, to identify questions and structure activities most likely to yield outcomes relevant to those interests." (see Figure 1).

Adapting the framework (Shirk et al. 2012) to the Amazonian context, first, we propose to incorporate the degree to which rights of Indigenous and local peoples over land, resources, and knowledge are acknowledged and respect, which in turn shapes the negotiation between scientific interests and public interests (and rights) to design and implement research projects/initiatives. This process ultimately influences the resulting observations, experiences, and outcomes in terms of science, socio-ecological systems, and communities and individuals (see David-Chavez and Gavin 2018; Liboiron et al. 2018; Carroll et al. 2021; Liboiron 2021). Second, existing institutions (norms), political structures, and civil society's strength and agency of (the organized public) also influence the ability of uptaking knowledge in decisions and, thus, in outcomes and impact resulting from those decisions and/or policies

This framework can be used to analyze not only experiences of public participation in knowledge generation and sharing, but also to design projects, helping to explicitly question and make decisions about citizen engagement or dialogue between diverse knowledge in each step of the process. Core decisions ultimately come down to who participates and who makes the decisions in the different steps of the process, i.e., who has primary authority over the process.

To organize the illustrative experiences shared in this chapter, we use the classification proposed by Shirk et al. (2012), which describes forms of public participation in scientific research without differentiating whether the public are IPLCs, other civil society organizations, or individual citizens. For authors that focus on Indigenous peoples, see David-Chavez and Gavin (2018), who proposed a scale for assessing levels of participation of Indigenous communities in research, and Liboiron et al. (2018), who proposed protocols and methods to reach agreements between researchers and Indigenous communities. Also, Liboiron (2021) proposed specific methods to carry out scientific research in Indigenous lands without reproducing colonial (extractive) relationships between mainstream scientists and Indigenous peoples:

"As director of CLEAR, I identify our space as an anticolonial lab, where anticolonial methods in science are characterized by how they do not reproduce settler and colonial entitlement to Land and Indigenous cultures, concepts, knowledges (including Traditional Knowledge), and lifeworlds. An anticolonial lab does not foreground settler and colonial goals. (...) Anticolonial here is meant to describe the diversity of work, positionalities, and obligations that let us "stand with" one another as we pursue good land relations, broadly defined." (Liboiron 2021, p. 27).

The illustrative experiences included in this chapter, organized using Shirk et al. classification, are summarized in Table 1 (adapted from Shirk et al. 2012). Given the focus of this chapter, all illustrative experiences reflect the most intense forms of public participation in scientific research or monitoring, i.e., collaborative, co-created, and collegiate projects (contractual and contributory experiences were left out of this analysis).

In addition, the illustrative experiences included in this chapter reflect the different types of outcomes that may result from public participation in knowledge generation and sharing (see summaries below and Annex 2 for full descriptions). First, in all cases, there was an increase in the capacities of participating citizens (individuals, communities, associations), as well as improved terms of engagement with government or scientific stakeholders.

Illustrative case studies organized by model of ppsr projec, based on degree of public participation in scientific research

	Models of public participation in scientific research (PPSR), as per Shirk et al. 2012 Table 1				
	"Contractual projects, where communities ask professional researchers to conduct a specific scientific investigation and report on the results"	"Contributory projects, which are generally designed by scientists and for which members of th epublic primarily contribute data"	"Collaborative projects, which are generally designed by scientists and for which members of the public contribute data but also help to refine project design, analyze data, and/or disseminate findings"	"Co-created projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process"	"Collegial contributions, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals."
The History of the Matapi: The documentation of local knowledge by their own experts (Colombia)					✓
Peasant knowledge for territorial planning in a context of conflict (Colombia)					✓
Chiribiquete: Natural and Cultural Heritage of Humanity (Colombia)					✓
Kukama Indigenous Peoples' Underwater World (Peru)					✓
The Territory of the Yuruparí Jaguars (Colombia)				✓	
Piraiba local knowledge: The fishermen's knowledge (Colombia)				✓	
Biodiversity as a Form of Sexual education (Colombia)				✓	
Training Indigenous Environmental Agents in the Southern Brazilian Amazon			✓		
Citizen science as a tool for fisheries monitoring using the Ictio App in the Madeira River Basin (Brazil)			✓		
The Citizen Science for the Amazon Network: and Amazon-wide collaboration to understand large-scale fish migrations (Bolivia, Brazil, Colombia, Ecuador and Peru)			✓		
Collaborative Knowledge Production and Coalition Building for Conservation Action through Rapid Biological and Social Inventories (Colombia, Peru)			✓		

Figure 33.1 Illustrative case studies organized by model of public participation in scientific research projects, based on degree of public participation in scientific research.

For instance, the cases "The Matapi History," "Visions of Chiribiquete," "Kukama Indigenous Peoples' Underwater World," "the Jaguars of Yuruparí," and "Biodiversity as a Form of Sexual Education" all qualitatively show an increase in understanding and recognition of ILK of Amazon ecosystems and Indigenous territories by mainstream science and key government agencies. The cases, "Training Indigenous Environmental Agents in the Southern Brazilian Amazon," "Citizen Science as a Tool for Fisheries Monitoring Using the Ictio App in the Madeira River Basin," and "Collaborative Knowledge Production and Coalition Building for Conservation Action through Rapid Biological and Social Inventories" all tell stories of how community-based monitoring and citizen science are contributing to strengthening the negotiation capacities of Indigenous peoples and fisher associations with government agencies and private stakeholders. In these cases, ILK contribution to territorial and natural resource management and conservation is recognized, and common or negotiated visions for the territory are attained or under construction.

Second, in all cases, there were important outcomes attained in terms of science or knowledge generation and sharing. Noteworthy cases include "Piraiba Local Knowledge," which tells the story of how local knowledge resulted in a five-fold increase in the number of prey species of giant Piraiba catfish, and "The Citizen Science for the Amazon Network," which describes how to build a shared fisheries database across the entire Amazon Basin.

Third, some illustrative experiences reflect on the impacts on social-ecological systems. For instance, "The Matapi History" case was critical in informing governance in the Colombian Amazon through the incorporation of a legal figure known as "macro-territories." The case "Peasant Knowledge for Territorial Planning in a Context of Conflict" explains how peasant knowledge was used to inform territorial and land-use planning in Colombia and recede conflicts between agricultural land-use and protected areas. Finally, "The Kukama Indigenous Peoples' "Underwater World" case made cultural river values visible by government agencies and civil society organizations and informed a public review of the environmental impact assessment for a waterway project.

33.2.1 Illustrative experiences of collegial contributions

- *Peasant Knowledge for Territorial Planning in a Context of Conflict (Colombia).* "Colono" settlers arrived in the Amazon piedmont in Caquetá, Colombia, toward the turn of the twentieth century. After conflict arose between their historical use of land for agriculture and the more recent creation of protected areas in the region, peasant knowledge informed and attained revisions of land use planning and conservation policies, overcoming conflict, and promoting conservation (FAO and ANT 2018, Arncop and Incoder 2012).

- *Visions of Chiribiquete from the Shamanic World (Colombia).* With a research grant from Tropenbos, Colombia, traditional knowledge holder Uldarico Matapí documented the Indigenous vision of the Chiribiquete National Park (Matapí Yucuna 2017). He described how Chiribiquete's famous pictographs depict the origin and rules of the world, in which territories, animals, water, plants, and shamanic knowledge were distributed to maintain the order of the rainforest. This knowledge currently informs national park management and promotes conservation.

- *Kukama Indigenous Peoples' Underwater World (Peru).* Leonardo Tello and the Radio Ucamara Civil Society Organization led a 5-year participatory process with Kukama Kukamiria Indigenous communities in the Lower Marañon River (Loreto, Peru) to map and document their ancestral knowledge and vision about sacred places, history, and culture. With support from Wildlife Conservation Society (WCS) and Florida International University (FIU) landscape ecologists, this knowledge was compiled into a story map: Parana Marañún tsawa: The Soul of the Marañón River. Submerged stories of the Kukama People. The Kukama People and civil society organization have used this story map to inform government agencies about the potential impacts of ill-planned infrastructure on the Kukama's territories and lives.

33.2.2 Illustrative experiences of Co-Created Projects

- *The Territory of the Jaguars of Yuruparí (Colombia).* This publication (ACAIIPI 2021) is a compilation of ILK by dozens of traditional knowledge holders from five Indigenous peoples in the Pirá Paraná River, Vaupés (Colombia) region. The book resulted from a collaboration between the ACAIPI Indigenous organization and the civil society organization Fundación Gaia Amazonas, and an intergenerational and intercultural collaboration between Indigenous wisepersons (sabedores) and youth, and western researchers. It describes the origins, livelihoods, and territorial environmental management vision of these five Indigenous peoples and aims to share and make this knowledge visible to both Indigenous peoples in the Pirá Paraná River (with a sense of pride) and foreigners (so they can understand each other better).

- *Fisherfolks' local knowledge about Piraiba (Colombia).* Biologist Carlos Rodríguez, fisherman Luis Angel Trujillo, and other researchers collaborated to compile and document ILK about Amazon giant catfish in the Lower Caquetá River (Colombia). Trujillo made a significant contribution through the research design and knowledge about the giant Piraiba catfish (Brachyplatystoma capapretum): he identified 93 prey species for this species, whereas prior scientific research had identified only 17. Then, Trujillo, Rodríguez, and Confucio Hernández, a Uitoto Indigenous expert illustrator, collaboratively published the book "Piraiba: Illustrated ecology of the great Amazon catfish" in 2018 (Trujillo et al. 2018), which was awarded the highest Colombian National Research Award.

- *Biodiversity and human health (Colombia).* Indigenous Elder nɨpodɨmakɨ Oscar Romualdo Román-Jitdutjaaño and anthropologist Juan Alvaro Echeverri collaborated in an intercultural study (Jitdutjaaño et al. 2020) of the human condition. They researched the plants from which alkaloid vegetable salts can be extracted. Increased understanding of these plant species and the services they provide to a common objective (e.g., food, tobacco, money, tools) in turn provide guidelines for behavior to develop a human body that is healthy, sociable, and fertile.

33.2.3 Illustrative experiences of Collaborative Projects

- *Training Indigenous Environmental Agents in the Southern Brazilian Amazon (Brazil).* In 2020, 73 Indigenous Environmental Agents (AAIs; acronym in Portuguese) participated in a training program led by the Institute of Education of Brazil (IEB) and the Parintintin, Jiahui, Tenharim, and Apurinã Indigenous Peoples. The program seeks to reflect on concepts, practices, techniques and technologies to support sustainable development and environmental security. Ultimately, the training program aims to increase Indigenous participants' technical and political capacities to face a range of socio-environmental challenges that affect their territories. As a result of this process, AAIs shifted their own and outsiders' perceptions from one where Indigenous peoples are seen as victims or obstacles to national development to one where they are seen as people whose actions are essential for environmental protection and authentic and sustainable development.

- *Citizen Science for Fisheries Monitoring: The Ictio App in the Madeira River Basin (Brazil).* Before this project, the only entity that generated and held fisheries data in Rondônia was a hydroelectric dam concession holder, limiting access of fisherfolk and government agencies to data and inhibiting their participation in decision-making. However, local scientists and fisherfolk recently agreed to test and implement citizen science approaches and the Ictio App (Ictio.org, see also next experience) to ensure that both state decision-makers and fishers generate and effectively access fisheries data. As a result, community members were empowered to monitor and co-manage fisheries, by uniting formal and traditional governance, and to use their own data to address potential impacts of the two hydroelectric projects operating in the Madeira Basin.

- *The Citizen Science for the Amazon Network (Amazon Basin-wide)* describes the collaboration between over 30 partners from different backgrounds, countries, and interests, to increase the understanding of Amazon migratory fish and foster sustainable fisheries management across the entire Amazon Basin. As of July 2021, using low cost, user-friendly digital tools and transparent knowledge sharing agreements, network partners and 70+ citizen scientist groups (e.g., fisherfolk, IPLCs, students) have generated and shared 55,000+ observations of 20+ migratory and food fish species across the Basin using the Ictio App and shared database (see Ictio.org, World Bank, 2021).

- *Collaborative Knowledge Production and Coalition Building*. Over 20 years of rapid inventories led by the Field Museum has informed conservation recommendations in the region. Rapid inventories have generated integrated, collaborative knowledge and informed conservation actions throughout Andean Amazon countries. Inventories are collaboratively designed and carried out with diverse actors at the local, regional, national, and international scales. Similarly, recommendations are co-created with local people and multiple stakeholders based on the rapid inventories results (Pitman et al. 2021; Wali et al. 2017).

- The experiences summarized here offer examples of projects where the terms of collaboration between mainstream scientists, practitioners, government agencies, and IPLCs were negotiated (implicitly or explicitly) and implemented. These offer important inspiration and lessons to address inequities in knowledge generation, sharing, and use, which are presented in the next section.

33.3 Discussion and recommendations

Based on the discussions and illustrative experiences presented in this chapter, and on our combined knowledge, we propose the following recommendations that will contribute to addressing inequities in knowledge generation and sharing for informed decision-making in the Amazon. These recommendations are not exhaustive but rather a starting point to build a sustainable Amazon that values and recognizes the contribution of diverse knowledge and societal engagement in knowledge generation and sharing to inform decisions and policies. Therefore, addressing inequities in terms of knowledge generation, sharing, and access to inform decisions involves:

- Respecting and guaranteeing the fundamental rights of people and nature, recognizing ILK, and guaranteeing IPLC rights to land as a critical first condition (see Annex 1, Liboiron 2021).

- Strengthening the design and enactment of open and collaborative knowledge principles through specific and targeted policies, agreements, and/or protocols appropriate to the Amazonian context.

- Developing open and collaborative knowledge policies, agreements, and ethical protocols are necessary for each step of the knowledge generation, sharing, and informing processes. These should be specific rather than general and should include, for example:

  a) Free prior and informed consent and participation agreements clearly outlining the risks and benefits of participation and who has the decision-making authority (see David-Chavez and Gavin 2018; Liboiron et al. 2018; Liboiron 2021);

b) Agreement terms for data access and management, including data quality assessment, interoperability, and aggregation of data across scales and countries (see Bowser et al. 2020 on citizen science data; Wilkinson et al. 2016 on FAIR Data Principles; and other global initiatives to improve data management practices and governance) ;
c) Intellectual property rights and licensing agreements;
d) Transparent and effective instruments for equitable and just distribution of risks and benefits associated with knowledge sharing, including crediting contributions (see Liboiron et al. 2017);
e) Investing in and access to innovative technologies that are low-cost, user-friendly, and effective to facilitate public participation, transparency, and scaling-up.

In many cases, these considerations are subject to rapidly evolving fields of study and very dynamic. However, key guidelines and sources of information on how to design and implement them can be found in instruments such as the Principles of Open and Collaborative Science (OCSDNet 2015), UNESCO'S recommendation on Open Science (UNESCO 2020), Research Data Alliance, Citizen Science Association, and European Citizen Science Association.

- Promoting collaborative research among IPLCs, practitioners, and academics. The contribution of ILK, knowledge dialogues, and public engagement in science to devising and implementing solution pathways towards a sustainable Amazon is still not well understood or visible among decision-makers in both Amazon countries and at a global scale. To address this challenge, IPLCs, practitioners, and academics should collaborate to lead compilation and dissemination efforts, with clear research agreements or contracts.

- Addressing imbalances of power with respect to knowledge through creating spaces for ILK in academia, and building bridges for equitable and just collaboration between academia, IPLCs, and non-academic knowledge. Similarly, we propose to open up government agencies to acknowledge and support ILK contributions to solution pathways toward Amazon sustainable development. This includes training courses for academics and government agency staff on intercultural contexts and knowledge dialogues; expanding the practice of allowing students to defend their theses or researchers to present their findings in Indigenous languages, as well as increased education in Indigenous and local languages; creating dialogue and exchange settings; and ensuring that the Amazon is prioritized in national and international science and technology agendas and investments.

- Building and strengthening multiple intercultural platforms for knowledge dialogue among general, technical, and scientific knowledge; arts; and ILK. This process could start by strengthening partnerships with IPBES and with national science and technology agencies and councils, and building effective national and regional platforms for exchanging experiences on ILK. Then, initial knowledge dialogue platforms may start at universities and research centers with the inclusion of ILK holders and local experts as faculty members. Cátedra Amazonas offers a model for multiple disciplines including natural sciences, social sciences, humanities, arts, engineering, and business management. Also, intercultural working groups with the participation of scientists, practitioners, and ILK holders (conocedores locales) could lead thematic seminars to address an agenda of previously agreed-upon priority issues. A specific priority is to maintain a permanent Amazon-wide knowledge dialogue platform involving the Coordinator of Indigenous Organizations of the Amazon River Basin (COICA) and other IPLC organizations, academia, civil society organizations, and government institutions.

- Organizing an Amazon Congress on ILK. This could be co-led by COICA, the Amazon Cooperation Treaty Organization (OTCA), or other Amazon multilateral organizations, and national-level Indigenous organizations, ministries or councils of science and technology, as well as other civil society organizations, to organize an Amazon Congress on ILK every two years. It is critical to secure continuity of this initiative over time to create and strengthen intercultural networks that involve stakeholders from IPLCs, academia, civil society organizations, and governments to devise joint/collaborative solutions for sustainable development in the Amazon.

- Ensuring that knowledge and evidence are effectively used in decision-making towards Amazon sustainable development. Public engagement in knowledge generation and sharing is critical but not enough; it needs to be complemented by public engagement in management and policy decisions. Representativeness, transparency, and accountability need to be critical elements of knowledge-based organizations and solutions.

- Addressing unequal access to information and communication technologies, connectivity, and critical research infrastructure capacities. The COVID-19 pandemic surfaced weak and unequal access to information and communication technologies, connectivity, and critical research infrastructure capacities (e.g., laboratories, research facilities, training). Therefore, it is urgent to address these gaps in ways that are appropriate to the Amazon context (diverse, multicultural, urbanized, and containing vast rural areas with low population densities).

33.4 Conclusions

Sustainable pathways for the Amazon require, first and foremost, the recognition and respect of the fundamental rights of humans, nature, and ILK. ILK has informed and continues to inform territorial and natural resource management, as well as conservation and sustainable development initiatives, especially those led by IPLCs themselves. However, the lack of appropriate recognition or internalization of ILK and other non-accredited knowledge, still hinders just knowledge production and informed decision-making at national and international scales. Existing solutions to the problem of unequal knowledge production, sharing, and articulation in decision-making must be described, disseminated, scaled up, and mainstreamed. At the same time, local, regional, and global professional associations and organizations are producing critical policy recommendations and guidelines that can inform the pathways forward.

Interventions at various scales are recommended to address these inequities in knowledge production, sharing, and informed decision-making, emphasizing the need to guarantee fundamental human and nature rights; recognizing ILK; and fostering an honest dialogue between different knowledge systems; enabling and promoting public participation in science and knowledge generation and sharing; and adhering to, and operationalizing, the principles of open and collaborative knowledge.

33.5 Recommendations

- Recognize and guarantee the fundamental rights of people and nature, as well as the knowledge systems of Indigenous people and local communities (IPLCs).
- Strengthen the design and implementation of open and collaborative knowledge principles through policies, agreements, and protocols. These should be targeted and adapted to specific contexts, objectives, and needs.

- Promote collaboration between IPLCs, practitioners, and academics to synthesize and disseminate knowledge to increase our collective understanding of the contribution of ILK and public engagement to science and Amazonian solutions.
- Invest in infrastructure for strengthening public participation in knowledge dialogues at various scales.
- Collaboratively create context-specific normative frameworks, agreements, and protocols for open and collaborative knowledge.
- Create, strengthen, and scale up intercultural knowledge platforms.
- Promote structural change and training for decision-making institutions to promote engagement with IPLCs, enhance public participation, and ensure transparency and accountability.
- Build on the progress made by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), regional and global partnerships, and emblematic knowledge dialogue platforms, and involve the leadership of IPLC and grassroots organizations, academia, civil society, and national science councils or ministries.

33.6 References

Arruda EP and Arruda DEP. 2015. Educação à distância no Brasil: políticas públicas e democratização do acesso ao ensino superior. Educ em Rev 31: 321–38.

Athayde, S.; M. Mathews; S.Bohlman; ... A. Oliver-Smith and D. Kaplan. 2019. Mapping Research on Hydropower and Sustainability in the Brazilian Amazon: Advances, Gaps in Knowledge and Future Directions. Current Opinion in Environmental Sustainability 37: 50-69.

Athayde, S.; J. Silva-Lugo; M. Schmink and M. Heckenberger. 2017. Re-connecting art and science for sustainability: learning from Indigenous artistic knowledge through long-term participatory action-research in the Amazon. Ecology and Society 22(2):36. https://doi.org/10.5751/ES-09323-220236.

Athayde, S.; R. Stepp and W. Ballester. 2016. Engaging Indigenous and Academic Knowledge on Bees in the Amazon: Implications for Environmental Management and Transdisciplinary Research. Journal of Ethnobiology and Ethnomedicine 2016, 12:26. DOI: 10.1186/s13002-016- 0093-z

Barthel R and Banzhaf S. 2016. Groundwater and surface water interaction at the regional-scale–a review with focus on regional integrated models. Water Resour Manag 30: 1–32.

Benjamin, R. 2019. Race after Technology: Abolitionist Tools for the New Jim Code. Cambridge: Polity.

Benyei P, Arreola G, and Reyes-García V. 2020. Storing and sharing: A review of Indigenous and local knowledge conservation initiatives. Ambio 49: 218–30.

Bowser A, Cooper C, Sherbinin A De, et al. 2020. Still in need of norms: the state of the data in citizen science. Citiz Sci Theory Pract 5.

Bradshaw GA and Borchers JG. 2000. Uncertainty as Information: Narrowing the Science-policy Gap. Conserv Ecol 4: art7.

Carroll SR, Herczog E, Hudson M, et al. 2021. Operationalizing the CARE and FAIR Principles for Indigenous data futures. Sci Data 8: 108.

Cash DW, Clark WC, Alcock F, et al. 2003. Knowledge systems for sustainable development. Proc Natl Acad Sci 100: 8086 LP – 8091.

Congretel M and Pinton F. 2020. Local knowledge, know-how and knowledge mobilized in a globalized world: A new approach of Indigenous local ecological knowledge. People Nat 2: 527–43.

Conrad CC and Hilchey KG. 2011. A review of citizen science and community-based environmental monitoring: issues and opportunities. Environ Monit Assess 176: 273–91.

Cooper CB, Shirk J, and Zuckerberg B. 2014. The Invisible Prevalence of Citizen Science in Global Research: Migratory Birds and Climate Change. PLoS One 9: e106508.

David-Chavez DM and Gavin MC. 2018. A global assessment of Indigenous community engagement in climate research. Environ Res Lett 13: 123005.

Doria CR da C, Lima MAL, and Angelini R. 2018. Ecosystem indicators of a small-scale fisheries with limited data in Madeira River (Brazil). Bol do Inst Pesca 44: e317.

Dorninger C, Hornborg A, Abson DJ, et al. 2021. Global patterns of ecologically unequal exchange: Implications for sustainability in the 21st century. Ecol Econ 179: 106824.

DuBay S, Palmer DH, and Piland N. 2020. Global inequity in scientific names and who they honor. bioRxiv: 2020.08.09.243238.

Elbein, A. 2020. "The Bird World is Grappling with its Own Confederate Relic: McCown's Longspur." Audubon. https://www.audubon.org/news/-bird-world-grappling-its-own-confederate-relic-mccowns-longspur

Fraisl D, Campbell J, See L, et al. 2020. Mapping citizen science contributions to the UN sustainable development goals. Sustain Sci 15: 1735–51.

Fritz S, See L, Carlson T, et al. 2019. Citizen science and the United Nations Sustainable Development Goals. Nat Sustain 2: 922–30.

Guisan, A. et al. 2013. Predicting species distributions for conservation decisions. Ecology Letters 16: 1424-1435. DOI: 10.1111/ele.12189

Harding, S. (1992). After the neutrality ideal: Science, politics, and" strong objectivity". Social research, 567–587.

Haraway D. 1988. Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective. Fem Stud 14: 575–99.

International Society of Ethnobiology. "Declaration of Belém." Accessed September 21, 2021. http://www.ethnobiology.net/what-we-do/core-programs/global-coalition-2/declaration-of-belem/.

Inoue CYA and Moreira PF. 2016. Many worlds, many nature(s), one planet: Indigenous knowledge in the Anthropocene . Rev Bras Política Int 59.

Jacobi J, Mathez-Stiefel S-L, Gambon H, et al. 2017. Whose Knowledge, Whose Development? Use and Role of Local and External Knowledge in Agroforestry Projects in Bolivia. Environ Manage 59: 464–76.

Jitdutjaaño R, Romualdo O, Román Sánchez S, and Echeverri JA. 2020. Ɨairue nagɨni Aiñɨko urukɨ nagɨni Aiñɨra urukɨ nagɨni Halogeno–Halofita Sal de vida. Universidad Nacional de Colombia Sede Amazonia-Instituto Amazónico de Investigaciones IMANI.

Lahsen M and Nobre CA. 2007. Challenges of connecting international science and local level sustainability efforts: the case of the Large-Scale Biosphere–Atmosphere Experiment in Amazonia. Environ Sci Policy 10: 62–74.

Liboiron M. 2021. Pollution is colonialism. Duke University Press.

Liboiron M, Ammendolia J, Winsor K, et al. 2017. Equity in author order: a feminist laboratory's approach. Catal Fem Theory, Technoscience 3.

Liboiron M, Zahara A, and Schoot I. 2018. Community peer review: A method to bring consent and self-determination into the sciences.

Lopes PFM, Freitas CT, Hallwass G, et al. 2021. Just Aquatic Governance: The Amazon basin as fertile ground for aligning participatory conservation with social justice. Aquat Conserv Mar Freshw Ecosyst 31: 1190–205.

Matapí C and Matapí U. 1997. Historia de los Upichia. Tropenbos.

Matuk FA, Behagel JH, Simas FNB, et al. 2020. Including diverse knowledges and worldviews in environmental assessment and planning: the Brazilian Amazon Kaxinawá Nova Olinda Indigenous Land case. Ecosyst People 16: 95–113.

McDonnell J. 2020. Municipality size, political efficacy and political participation: a systematic review. Local Gov Stud 46: 331–50.

McElwee P, Fernández-Llamazares Á, Aumeeruddy-Thomas Y, et al. 2020. Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment. J Appl Ecol 57: 1666–76.

McKinley DC, Miller-Rushing AJ, Ballard HL, et al. 2017. Citizen science can improve conservation science, natural resource management, and environmental protection. Biol Conserv 208: 15–28.

Meneghini, R. et al. 2008. Articles by Latin American authors in prestigious journals have fewer citations. PLoS One, 3(11): e3804.

Mongabay. 2020. "The Amazon Rainforest: The World's Largest Rainforest." https://rainforests.mongabay.com/amazon/

Newig J and Moss T. 2017. Scale in environmental governance: moving from concepts and cases to consolidation. J Environ Policy Plan 19: 473–9.

Nicholson, E. et al. 2013. "Testing the focal species approach to making conservation decisions for species persistence." Diversity and Distributions 19: 530-540. DOI: 10.1111/ddi.12066

Nobre CA, Sampaio G, Borma LS, et al. 2016. Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. Proc Natl Acad Sci 113: 10759–68.

OCSDNet. 2015. Understanding opportunities and barriers of open and collaborative science for development in the global South (OCSDNet - Open Collaborative Science in Development Network). Nairobi.

Preskill H and Catsambas TT. 2006. Reframing evaluation through appreciative inquiry. Thousand Oaks: Sage Publications Sage CA: Thousand Oaks, CA.

Pretty J, Adams B, Berkes F, et al. 2009. The Intersections of Biological Diversity and Cultural Diversity. Conserv Soc 7: 100–12.

Quintero Toro, C. 2012. Birds of Empire, Birds of Nation: A History of Science, Economy, and Conservation in United States–Colombia Relations. Bogotá: Universidad de los Andes.

Roach, A. 2020. "Ornithologists call for birds named after people with links to slavery or racism to be changed." Evening Standard. https://www.standard.co.uk/news/world/ornithologists-birds-racist-slavery-name-changes-a4517176.html

Rusu. 2019. "Why we should all care about the Amazon rainforest." Ethical.net. https://ethical.net/ethical/care-about-the-amazon-rainforest/

Santos MJ dos, Silva Dias MAF, and Freitas ED. 2014. Influence of local circulations on wind, moisture, and precipitation close to Manaus City, Amazon Region, Brazil. J Geophys Res Atmos 119: 13,213-233,249.

Shirk JL, Ballard HL, Wilderman CC, et al. 2012. Public Participation in Scientific Research: a Framework for Deliberate Design. Ecol Soc 17: art29.

Trujillo LÁ, Rodríguez C, and Hernández C. 2018. Piraiba: ecología ilustrada del gran bagre amazónico. Colombia.

UNESCO. 2017. Recommendation on Science and Scientific Researchers. In: Records of the General Conference, 39th Session. Paris.

Whyte, K. 2013. On the role of traditional ecological knowledge as a collaborative concept: a philosophical study. Ecol Process 2, 7 (2013). https://doi.org/10.1186/2192-1709-2-7

WWF. 2013. "Go and make disciples: Five reasons to care about the Amazon and five reasons you can do to help." https://wwf.panda.org/discover/knowledge_hub/where_we_work/amazon/special_topics/faiths_for_conservation_wyd/five_reasons_to_care__five_things_to_do_for_the_amazon/?#:~:text=The%20Amazon%20forests%20play%20a,continent%20with%20life%2Dgiving%20rainfall

Yale University. 2020. "The Global Forest Atlas: The Amazon Basin Forest." https://globalforestatlas.yale.edu/region/amazon

Yucuna UM. 2017. Mejeimi Meje: Ecos del Silencio Chiribiquete: Patrimonio Vivo del Conocimiento Upichía Asociado al Cuidado de la Diversidad. Rev Colomb Amaz 10: 294.

ANNEX 33.1. Proposal summary of a conceptual framework for the future of the Amazon

Proposal summary of the Amazon future vision conceptual map

(Version for comments and review by the participants of the meeting "In search of a more sustainable and just future for the Amazon," 2/Sep/2020)

This is a proposal summary of the vision map of the future of the Amazon, prepared in a participatory way during the Virtual Meeting held by WG12 on 2 September 2020, "In search of a more sustainable and just future for the Amazon". The content of this text still needs to be reviewed and validated by the participants of the meeting. A table with the summary of the vision and values is attached.

What is your vision for the future of the Amazon?

Recognition and respect for Indigenous, traditional and local rights and knowledge.[16]

The virtual meeting with representatives of Amazonian peoples and organizations was held on September 2, 2020, within the scope of Working Group 12 (WG12) of the Scientific Panel for the Amazon (SPA)[17], and gathered numerous contributions on the vision of the future for the Amazon. From the set of visions that we were able to compile (see list in the Memory of the Virtual Meeting), it seems there is a collective vision based on two fundamental pillars: (1) the need for recognition and respect for capital rights, among them and, in particular, the right to land and (2) the recognition and inclusion of Indigenous, traditional and local knowledge in decision-making about the future of the region. The group, in general, seems to converge around the opinion that these two pillars are the foundations for maintaining the socio-environmental integrity of the region and human well-being inside an outside the region. If recognition and full respect for Indigenous, traditional and local rights and knowledge are achieved, the result should be an effective incorporation of this knowledge into public policies.

Incorporation of Indigenous, traditional and local knowledge into public policies and planning to manage natural resources.

Assuming the two pillars mentioned above are valid, the incorporation of Indigenous, traditional and local knowledge into decisions and public policies should be effective and influential. Otherwise, there will be no possibility of treading a new path towards a sustainable Amazon for everyone. In this sense, incorporation must be carried out respecting the diverse spirituality present in the region and under the precepts of gender identity[18], generational issues and the inclusion of ancestral values. Only in this way will the focus be effectively intercultural, allowing fair treatment of Indigenous, traditional and local knowledge in processes of construction or improvement of public policies for the Amazon, breaking with the colonialist notion historically present in the region.

Strengthening territorial governance by indigenous peoples and traditional communities.

---

[16] We consider traditional knowledge that offered by traditional communities (ribeirinhos, quilombolas, etc.), Indigenous peoples, small farmers and extractivists.

[17] https://www.laamazoniaquequeremos.org

[18] The way in which an individual identifies in society, based on the identification of that individual with a certain gender (male, female or both), regardless of sexual orientation.

Respect for rights and the inclusion of Indigenous, traditional and local knowledge in decision-making is one of the most effective ways to achieve full territorial governance by Amazonian peoples, regardless of their nationality. The result will be a more sustainable Amazon and greater legal certainty regarding the protection of territorial rights. As already mentioned, this governance will only be complete with the autonomous management of the territory, with the due participation of women and young people.

Conserve the Amazon forest and its essential ecosystem services, such as climate regulation, rainfall, and the maintenance of biodiversity

Without effective governance of territories, conservation in the Amazon will not be assured. Forests inside Indigenous lands, for example, have an insignificant rate of forest destruction (<1%) compared to other lands (>30%). This justifies attributing the title of "guardians of the forest" to Indigenous peoples. But such a title will only be genuine if the autonomous management of the territory is ensured, as well as recognition and respect for their cultures and rights, including, in particular, Indigenous peoples in voluntary isolation and initial contact.

Attention to the destruction and degradation of the forest and aquatic ecosystems, and threats to biodiversity (fauna, flora)

Recognition and respect for rights will only be achieved if traditional and local communities and Indigenous peoples continue to conserve the territories inherited from their ancestors. This seems the main way to combat the threats suffered. It is also necessary for each Indigenous people or community to self-determine its way of living and developing and, even if they decide to live or develop in the urban/western way, that they can do so without losing their customs. Thus, it will be possible to continue with the benefits of the conservation of territories and the environmental benefits they provide, in addition to ensuring food and health security, always taking into account ancestral values and knowledge. It will be the means to raise awareness and publicize the importance of the Amazon to the world and develop fair markets guided by sustainability and by fostering a bioeconomy based on biodiversity, knowledge and values/aspirations of the peoples of the region.

What are your personal values or the values of your community? What are the keys to building the future of the Amazon?

Values are important because they define the behaviors expected by society, whether universal or specific to some groups. In this case, participants identified the values needed to foster a sustainable future for the Amazon. These values were identified in writing in the communication before the meeting or during the meeting, and are summarized as follows:

Respect

Specifically, the sustainability and future of the Amazon depends on respect for individual, collective and territorial rights, especially the rights of Indigenous populations, who have their own views and conceptions about the integrity of their territories.

Honesty and Transparency

For fair work towards the future of the Amazon, honesty and transparency are needed, creating collaboration and collectivity. Processes must be clear, and by committing to honesty and transparency, you are also committing to the fight against corruption.

Collaboration and collectivity

When making decisions, you must think about collective values and what affects the common good. Throughout the process, the main actors must also be involved and facilitated, and reflection must be valued.

Solidarity

Valuing solidarity also means creating and valuing love of and passion for working towards a better future for the Amazon. The Amazon's people can advance when they understand, value and respect each other, creating conditions of equity.

Interculturality

The value of interculturality means that not only scientific knowledge, but also Indigenous, traditional and local knowledge is recognized. The knowledge and way of life of Amazonian peoples are valid and valued, promoting a direct and genuine listening to the territory and its people. This intercultural approach also means advocacy and governance where different voices and opinions are considered; promotes participatory democracy and is aware of the different cultures, identities and spiritualities present; and how processes can impact them in different ways. It also means promoting a dialogue of shared knowledge where local solutions are seen as models and, thus, epistemological change is created.

Strengthening Amazonian citizenship

Strengthening Amazonian citizenship is necessary to maintain the integrity of the ecosystem and people's well-being. This means a political formation where the history of the people and the territory is known and, thus, better care can be taken, avoiding predatory actions on the territories and resources of the region. This also means autonomy for the peoples of the Amazon, so that they themselves make decisions that impact their future and can communicate to see the Amazon as a connected ecosystem. Furthermore, the voice of Amazonian citizenship must be projected so that it has its place in national and international instances.

Table 33.A1 Summary of shared visions and values shared in the meeting 02/09/20

VISÃO		VALORES
Recognition and respect for Indigenous, traditional and local rights and knowledge	↓	Historical knowledge, political training, advocacy Preservation and expansion of laws and principles that protect rights
Incorporation of Indigenous, traditional and local knowledge into public policies and natural resource management plans	↓	Gender, intercultural and intergenerational approach Emphasis on local solutions Respect for diverse spirituality Knowledge dialogues and knowledge sharing
Strengthening territorial governance by Indigenous peoples and traditional communities.	↓	Honesty and transparency Consider local protection and conservation technologies Collective ethics with a guide for communities Respect for the common heritage Collaboration and collectivity
Conserve the Amazon and its essential ecosystem services, such as climate regulation, rainfall, and the maintenance of biodiversity		Consider and connect diverse knowledge: scientific, Indigenous, traditional and local Social and environmental safeguards for development programs Prevent deforestation, destruction and degradation of ecosystems and predatory exploitation Mapping the vulnerabilities of Amazonian territories and ecosystems to climate and occupation threats in the region.
Amazonian citizenship		Recognition and respect for capital rights, especially the right to land. Inclusion of Indigenous, traditional and local knowledge in decision-making. Collective construction of the future, based on the exchange and sharing of diverse knowledge (scientific, Indigenous, traditional and local).

ANNEX 33.2. Illustrative experiences

The History of the Matapí: Documentation of local knowledge by their own experts

Country: Colombia
Summary Author: Carlos Rodríguez

The bibliography on Indigenous peoples is dominated by the authorship of social scientists, especially anthropologists, who in one way or another recognize local knowledge and express it in their works, and even mention local experts and highlight their texts under the figure of informants. This process of recognition of local knowledge has led to the increasing involvement of Indigenous people themselves as compilers of their own knowledge and authors of publications of all kinds, from a short history, through primers and articles to complete books, including book series.

Communities approach the process of telling, writing, and sharing their knowledge in diverse ways, depending on their goals. For instance, to strengthen their own cultures and to address concerns that their knowledge is being lost or eroded. Also, to share their knowledge with the outside world, including academia and government agencies, in a way that it can be recognized and taken into account in public policy decision-making.

In the Colombian Amazon, there are very good contributions authored by traditional knowledge holders who have compiled their own texts for more than 20 years. One of the pioneering cases was the book *The History of the Upichia*, authored by Carlos Matapi and his son Uldarico Matapi, published as a scientific series with an international editorial committee (Matapi 1997). This recognition of Indigenous knowledge was important because it contributed to making visible the knowledge accumulated by the elders and, in this case, to recognize in a broad way that Indigenous peoples have a historical depth of more than 13 generations in their memory. This is an oral history which follows specific codes, languages, and rituals. The history is also written in the forest and consolidates the notion of ancestral territory.

Indigenous authors prepared this publication over several months, transcribing their historical knowledge and drawing maps of the sites occupied by their ancestors in an exercise of their own cartography. This process allowed them to contribute to territorial planning, the designation of Indigenous territories (*Resguardos*), and clarification of the relations between the various Indigenous groups with whom the territory is shared. The process and the publication were a significant contribution to understanding the cultural contexts within the notion of macro-territory, an area shared by 30 different Indigenous peoples and a fundamental concept for the new Indigenous governance in the Colombian Amazon.

The volume became a reference material for academics and for local schools, since the Upichia could include their own views of history and also disprove those who considered that the Indigenous people did not have history. The publication has also encouraged other Indigenous groups to compile their own knowledge; other neighboring Indigenous peoples have carried out similar writing exercises, and currently there are several dozen publications with local Indigenous authorship.

References:
Matapí, Carlos, and Uldarico Matapí. 1997. *Historia de los Upichia*. Santafé de Bogotá: Tropenbos-Colombia.

Peasant knowledge for territorial planning in a context of conflict

Country: Colombia
Summary Author: Visnu Posada

The El Pato-Balsillas region is located in the northwestern part of the Department of Caquetá in what is known as the Amazon piedmont. It is crossed by a national road that connects the city of Neiva (Department of Huila) with San Vicente del Caguán (Department of Caquetá), one of the epicenters of peasant colonization in the Colombian Amazon.

Peasant settlement of this region took place between the end of the nineteenth century and the beginning of the twentieth century and was based on two processes: first, displacement produced by land distribution conflicts, mainly in the Magdalena River valley; second, cyclical "bonanza economies", attracting settlers during booms of quina, timber, furs, rubber, and coca.

The government supported some colonization processes, and agricultural and livestock planning explicitly promoted them. However, these were not coordinated with environmental agencies, at minimum to avoid siting them in areas unsuitable for production and designated as conservation units (mainly National Natural Parks and Forest Reserves). When created, conservation units did not foresee the necessary actions to prevent and address conflicts with peasant settlements. As a result, several conflicts between settlements and conservation units arose in the region. These conflicts were aggravated by the weak governance of the conservation units, which were in turn associated with (a) weak capacities of the National Natural Parks agency and (b) the dynamics of armed conflict present in these frontier areas.

During this situation, peasant settlements achieved high levels of awareness and organization that involved diverse policies and programs for managing their territory, including minimum and maximum land sizes; intervention percentages; permits for the use of natural elements; soil, water, wildlife and forest management; community infrastructure; conflict resolution; and non-intervention sites. These achievements were condensed into Community Action Boards and grassroots organizations with clear territorial jurisdictions but varied levels of organizational strength. These organizations negotiated with government agencies about multiple rural development aspects, but conflict with conservation units and other environmental planning policies were the main contention points.

The Pato-Balsillas Region provides a relevant case study for conflicting territorial dynamics; although conflicts were initially associated with easements for communication infrastructure and lack of governmental support for rural development, land use conflicts quickly surfaced, since conservation units limited the access of peasants to agricultural and livestock services (e.g., land, extension services, credit).

The settlement's economy was mainly based on extractive activities (timber) and illicit crops, which increased tension with local and environmental authorities. In the early 1980s, the Pato-Balsillas settlers organization, Asociación Municipal de Colonos del Pato (Amcop), began to negotiate an agreement with local and environmental authorities, a change in the productive model of two conservation units: the Amazon Forest Reserve and the Cordillera de los Picachos National Natural Park.

The most outstanding elements of the negotiations included halting deforestation, eradicating illicit crops, lifting the Forest Reserve (1984) designation, and agreeing on a new boundary for the National Park (1998) that would exclude most of the peasant families, relocate others, and pay for the most remote lands.

All these elements were agreed upon during years of negotiations with national and subnational government and environmental and other agencies. They were expressed in a new territorial management unit: the Peasant Reserve Zone (ZRC) for the Pato River Basin and the Balsillas valley (1997).

Colombian legislation started including Peasant Reserve Zones in 1994, as a response to the mobilization of peasant communities that demanded territorial recognition, through the promotion of their culture and economy, limitations to small and large holdings, and public investments. The first pilot Peasant Reserve Zone was developed in the region of Pato Balsillas, in Cabrera and Guaviare. It is the result of agreements between government environmental and agricultural agencies, conservation units, and the peasantry, generally located in agricultural frontier areas with relatively low levels of agricultural development. Peasant Reserve Zones aim to ensure the sustainability of both peasant life and ecosystems, and their main management instrument is the Sustainable Development Plan (PDS).

To date, the Peasant Reserve Zone (ZRC) for the Pato River Basin and the Balsillas valley has managed to maintain the Cordillera de los Picachos National Park without human intervention in the area adjacent to it, reduce internal deforestation to less than 1% of its territory per year, and find a productive system that allows peasant life to flourish.

At the end of 2020, the boundaries of the ZRC were updated as a result of the high levels of ecosystem preservation (more than 60% of the ZRC), and 2,730 ha of forest cover were converted into the first Regional Natural Park of the Colombian Amazon (Miraflores and Picachos). At the same time, the Ministry of Environment and Sustainable Development adjusted the limits of the Amazon Forest Reserve, allocating to the ZRC lands that were taken away from settlers in 1984. Also, foundations were laid to manage the expansion of the ZRC towards the Bajo Pato sub-region, after consultation with the neighboring Nasa Indigenous Community of the Altamira Resguardo.

References:
Amcop & Incoder. (2012). *Plan de Desarrollo Sostenible de la Zona de Reserva Campesina cuenca del río Pato y valle de Balsillas*.
FAO y ANT. (2018). *Las Zonas de Reserva Campesina. Retos y Experiencias significativas en su implementación. Aportes para una adecuada implementación de la ley 160 de 1994, la Reforma Rural Integral y las Directrices Voluntarias para la Gobernanza Responsable de la Tenencia de la Tierra*.

Chiribiquete: World Natural and Cultural Heritage Site
Country: Colombia
Summary author: Carlos Rodríguez

The Serranía de Chiribiquete National Natural Park, located in the southwestern end of the Guyanese shield in the Colombian Amazon, is one of the largest protected areas in the country, with 4,268,095 hectares. In 2018 it was listed as a site of mixed Cultural and Natural Heritage of Humanity by UNESCO. This area, in addition to having high biodiversity, has more than 70,000 pictographs, which give it an exceptional value in terms of the history of settlement and occupation of the Amazon.

Researchers have studied the area for nearly three decades (Castaño-Uribe 2019), including its geology, geomorphology, soils, water, vegetation, and fauna, together with the archaeological study of the pictographs. Several articles have been published in indexed journals and carefully-edited books. The literature on Chiribiquete mostly represents the perspective of accredited science, but one of the volumes of the *Revista Colombia Amazónica* includes the contribution of a traditional expert, Uldarico Matapí, who wrote the article "Echoes of Silence", which shows from the very title the magic and poetry of the place and its importance to Indigenous communities (Matapí Yucuna, 2017).

Uldarico Matapí, supported by a research grant from Tropenbos Colombia, has been documenting his vision of Chiribiquete as an area of great importance for shamanism, with the different phases of the origin of the world and its management rules presented in pictographs. Matapí, a shaman of the Upichía group, makes mental tours of the area to describe or tell its history, its role in the creation of the world, and how the mountains, rivers, and geographical features, such as huge round holes ("the echoes of silence"), were formed. In the same way, he has been compiling the shamanic meaning and the explanation or interpretation of the pictographs in which he finds the sequences of origin myths, songs, and rituals that order the world.

As a shamanic space, Chiribequete's pictographs tell stories about the origin of the rules of territorial management, how animals were dispersed to occupy their own territories, how plants and waters were distributed, and most importantly, how shamanic knowledge was distributed to maintain the order of the jungle. In this sense, Matapí contributes elements for governance from the traditional vision, since the area is formalized as a National Park, but its management should include the Indigenous communities for whom Chiribiquete is an ancestral site.

Matapí's compilation contributes to the dialogue of knowledge, to know first hand the traditional visions and not only the scientific research. In this sense, knowing and recognizing the importance of Indigenous knowledge contributes to better management of the area and highlights its role in cultural heritage, locally managed. Traditional knowledge can contribute elsewhere in similar ways, impacting new management and governance schemes for protected areas. It is therefore important to support contributions from traditional knowledge.

References

Castaño Uribe, Carlos, Parques Nacionales Naturales de Colombia, and Instituto Colombiano de Antropología e Historia. 2019. *Chiribiquete: La Maloka Cósmica de los Hombres Jaguar*. 1st ed. Bogotá, Colombia: Villegas Editores. https://issuu.com/chiribiquete/docs/fragmento_libro_gran_formato.

Matapí Yucuna, Uldarico. 2017. "Mejeimi Meje: Ecos del Silencio Chiribiquete: Patrimonio Vivo del Conocimiento Upichía Asociado al Cuidado de la Diversidad." *Revista Colombia Amazónica* 2017 (10): 294. https://sinchi.org.co/files/publicaciones/revista/pdf/10/4%20mejeimi%20meje%20ecos%20del%20silencio%20chiribiquete%20patrimonio%20vivo%20del%20conocimiento%20upichia%20asociado%20al%20cuidado%20de%20la%20diversidad.pdf.

Kukama Indigenous Peoples' underwater world, Peru

Country: Peru

Summary authors: Leonardo Tello and Natalia Piland

In the Lower Marañón River, Loreto, Peru, the Kukama Kukamiria Indigenous people collectively constructed a map that tells the story of these communities, a process that proved to be a powerful tool for reflection if humbly applied. In the face of external processes that threaten the lives of the people, such as logging concessions, oil exploitation, headwater mining, and over-extraction (e.g., fish, palm trees), the map communicates the relationships that are present in the day-to-day life of the communities and the living dynamics of the river. The river is not a physical entity but rather part of family and memory. This initiative was full of hope, struggle, and strength in defense of rivers, life, and people. Among the relationships that the map reveals are stories of the *pela-cara*, ghost ships, and submerged cities.

The *pela-cara* is a supernatural character with lights, guns, and airplanes. He is very fast and appears to chase fishers and boat drivers. He is a being that cannot be seen from the forest. This story is told mostly when mining and oil companies invade without respecting the space of the native peoples. Thus, the frequency with which this story is told reproduces relationships between communities and external agents, and a history of aggression and violence. The *pela-cara* story and its increased visibilioty can be used to identify where this is happening.

The river also carries the memory of the rubber boom. People see ghost ships in the same places where rubbe, rosewood (*Tipuana tipu*), and other materials exploited at that time were shipped from. When one sees ghost ships, the sighting can also be felt; one can feel the pain of the people through time. We not only remember the violence before, but also the current violence, because the violence of the past is the same violence with which governments, extractivists, and others act today. They contain the same promises and lies. The map shows many things that have happened in the history of the Amazon and the Kukama people.

The river also moves fish and provides drinking water, among other things. But when a person falls into the river and we do not find his or her body, it is because this person now lives inside the river. Thus, the river enters into a relationship with people—the river gives life to everything, and it also contains the lives of our relatives in submerged cities. These cities are the same as the ones we have outside the river. The river also becomes a vehicle of communication with our relatives, and our relationship with the river is also affective and spiritual.

Through these ways of knowing the river, one can understand that the river is alive. In the same way, it is understood that there are various groups of "people" (*"gente"*), not only humans, but also fish, birds, plants, and other living beings. This way of looking at the world makes possible a harmonious relationship that is not possible when power corrupts, makes people consider themselves superior to other people, or when we believe that we can change our surroundings without respecting the relationships we have with other people. Outsiders are ignorant and do not know that the *cochas* (lagoons) have mothers, that there are relationships with animals, and that spirits exist, and so they believe they can enter these lands, destroying everything and taking the people with them.

This map was constructed within the project The Soul of the Marañon River: Submerged Stories of the Kukama People. This project, spanning more than five years, was carried out by Radio Ucamara, an Indigenous media outlet, which collects the individual and collective stories and histories of hundreds of generations. Through an interactive map, visitors can dive into the depths of the river to learn about what cannot be seen with the naked eye: the memory and worldview of an entire culture. Through meetings and workshops with community leaders, religious animators, and other members of the Kukama people, the team gathered the information to map the significant places. Between September 2016 and October 2017, with the support of civil society organizations such as the Wildlife Conservation Society (WCS) Peru, four additional field trips were completed to georeference the elements identified in the maps, which were published within a StoryMap in 2020 (Radio Ucamara 2020).

The information compiled in this map and the location of each element of the cosmovision of the Kukama People shows us the importance rivers have for an entire culture and the tremendous social impact that the construction of poorly planned infrastructure brings; not only does it change the space where they live, but it could also destroy a part of their memory that can never again be recovered.

The map can also help with outreach to other people suffering similar things. The process of mapping a cosmovision and its political and cultural context can be done in other areas of the Amazon. In collaboration with CONFENIAE, an Indigenous federation in the Ecuadorian Amazon, Radio Ucamara is in the process of forming a network that gives Indigenous peoples the possibility of building policies and communications throughout the Amazon. The COVID-19 pandemic has made it more important to have this kind of alliance with courage. This experience can generate a new way of thinking about political relationships and the relationships of power in both ways. Large networks generate a lot of porosity and fall apart if they are not grounded in local experiences; with a map like this, we can generate local experiences that inspire a much larger movement. In addition to the map, the group is making films, animations, video clips, and recovering self-participating identities. Radio Ucamara is categorized as cultural radio, but is creating a movement that will sustain itself over time, just as the feminist movement is getting stronger.

The map is not just a map. It is full of lived, painful, and violent histories, and there could be a struggle as confrontational as that of the unions and other movements, but no one wants to lose any more lives. The struggle is at the creative level. We must be able to do beautiful things, and this map is just one step in this struggle that moves people through affection, rethinking, and collaboration and synergy. No one can resist a nice thing, and the map is just one of the nice things in this movement of Indigenous knowledge.

References:
Radio Ucamara. 2020. "Parana Marañún tsawa: El alma del Río Marañón. A Story Map." Story Map. 2020. https://www.arcgis.com/apps/Cascade/index.html?appid=2f9a6e6de49f4556b110dc005bc9cb2b.

The territory of the yurupari jaguars

Country: Colombia
Summary Author: Carlos Rodríguez

El Territorio de los Jaguares de Yuruparí (ACAIPI 2015) gathers the contributions of dozens of traditional knowledge holders of the Barasana, Eduria, Itana, Macuna, and Tatuyo peoples of the Pirá Paraná River in the Colombian Amazon, also known as the Territory of the Jaguars of Yuruparí. Through a long process of cultural strengthening, these Indigenous peoples captured their knowledge in written form as a way of transmission to young generations and the western or "white" world. In this way, they would better understand their visions of territorial management and their vision of the world.

UNESCO recognized traditional knowledge of the jaguars of the Yurupari as an Intangible Cultural Heritage of Humanity. This recognition entails the implementation of special measures for its protection and dissemination in governmental, academic, and cultural spheres. In this sense, the book makes visible the wealth of Indigenous knowledge about caring for the territory in one of the best-preserved areas of the Amazon.

This book was developed through a dynamic interaction between ACAIPI, the association of captains and traditional Indigenous authorities of the Pirá Paraná River, and the Gaia Amazonas Foundation, through a collaboration between Gaia researchers and several Indigenous youth groups, who also learned skills such as how to use technology for listening, learning, and transcribing Indigenous narratives and knowledge. In this way, they recorded, translated, and transcribed oral histories into Spanish and made dozens of drawings and maps to accompany the narratives. This process was nurtured by professionals in the natural and social sciences from the Gaia Foundation through an intercultural knowledge dialogue. Researchers and Indigenous groups designed a joint strategy to create research groups, one per Indigenous group, *maloca,* and community. The research groups defined priority research topics and selected the texts that would later be included in the publication.

The final selection of texts by local Indigenous experts does not correspond to a linear discourse, but rather to the integral vision that Indigenous peoples possess. However, for the purpose of publication, these texts were grouped into chapters by theme: Narrations or words of origin, origin of the prayers, the emergence of the people, the territory as a great *maloca*, the sacred places of power, and the ecological calendar. Each chapter includes contributions from different Indigenous experts as authors and highlights their personal stamp in terms of the different ways in which each person tells a story.

Through these written texts, Indigenous youth have valuable reference material for their own educational projects, whereas, for western society, this publication is a first-hand reference on Indigenous visions of the territory and their care for nature, and offers great lessons of environmental ethics that have enabled these Indigenous peoples to secure one of the best-preserved forest areas in the entire Amazon over thousands of years.

The impact of this publication also reaches the political sphere: it strengthened the case for self-government and autonomy of Indigenous peoples in the Colombian Amazon and may inform the design and implementation of public policies that respond to the cultural diversity of the nation. Indigenous and non-Indigenous researchers have made significant efforts to show the Indigenous world vision to subnational and national government authorities and to include this knowledge and practices in the concept of sustainability. In his prologue, the president of Colombia highlighted the agreements recently signed with Brazil to safeguard the immaterial patrimony of Indigenous peoples of the northwestern Amazon Basin.

References:
Hee Yaia Godo ~Bakari - El Territorio de los Jaguares de Yuruparí. Conocimiento Tradicional de las Etnias del Río Pirá Paraná para el Cuidado del Medio Ambiente. 2014. 1st ed. Vaupés, Colombia: Asociaciones de Capitanes y Autoridades Tradicionales Indígenas del Río Pirá Paraná (ACAIPI) & Fundación Gaia Amazonas. https://www.gaiaamazonas.org/uploads/uploads/books/pdf/El_Territorio_de__los_Jaguares_de_Yurupar%C3%AD__Gaia_Amazonas__ACAIPI__2012_.pdf.

Piraiba local knowledge: The fishermen's knowledge

Country: Colombia
Summary Author: Carlos Rodríguez

Scientific research on giant catfish in the Colombian Amazon dates back to the end of the 1970s, with studies from the Araracuara Corporation, a private institution that conducted research about giant catfish fisheries in the middle Caquetá River (Japurá in Brazil), including dorado (*Brachyplatystoma rousseauxii*), lechero or piraiba (*Brachyplatystoma capapretum*), pejenegro (*Zungaro zungaro*), guacamayo (*Phractocephalus hemiliopterus*) and pintadillo (*Pseudoplatystoma sp*). Early research focused on the definition of biological parameters for fisheries, such as catch sizes and sexual maturity sizes, to inform fisheries regulations. These early studies resulted in published articles that guided future research. On behalf of fishing authorities of that time, surveys were also conducted in the lower Caquetá River, very close to the border with

Brazil, and some fisheries regulations were established, including long periods of closure and limitations on the use of fishing nets—the predominantly used gear in the area.

In 1982, Carlos Rodríguez started a ten-year study of commercial fishing of giant catfish species, using information generated locally by fish traders (through fish inventories in commercial refrigerated chambers). This study was published as “Bagres, Malleros y Cuerderos en el Bajo Río Caquetá” (Rodríguez 1992) and presented a first-ever integrated analysis of historical, social, economic, and biological aspects of fisheries in an area of approximately 400 km^2 between the Cahuinarí River and the Brazilian border. Through participatory research methodologies, both fishers and traders refined and improved data collection methods to record information on catch parameters, fishing gear, catch areas, and fishing effort.

Research on biological, reproductive, and fishing aspects of giant catfish species continued over time with undergraduate and doctoral research and investigations by civil society organizations and research institutes (e.g., Instituto SINCHI), contributing to a better understanding of catfish species (Agudelo Córdoba et al., 2000). A popular topic was always feeding relationships of catfish, and many scholars tried to study this subject but found enormous limitations. Biological sciences approach this subject from the perspective of studying stomach contents, but researchers found empty stomachs in more than 95% of sampled catfish. Researchers then proposed to study the stomachs of all captured specimens by fish traders, but found fish arrived to cold chambers already eviscerated and that the research would interfere with the fish traders’ processing (e.g., evisceration, gutting, de-salting, and cutting the head).

More than two decades ago, Tropenbos began a participatory research process with Indigenous communities and local people aimed at supporting the exhaustive documentation of Indigenous and local knowledge about the Amazon forest, including plants, terrestrial and aquatic fauna, soils, geology, and social and cultural aspects of Indigenous and local visions of the forest and its resources. As part of this, through grants for local research, researchers supported Luis Angel Trujillo, a second-generation settler, to compile his own knowledge about catfish and their ecological relationships. Trujillo was selected as he often showcased his enormous knowledge and ability to share it with the biologists working in the region.

Trujillo learned the art of fishing as a child and began to master the world of water and fish, especially giant catfish species. At the time, fishing was almost the only source of cash income in the region, and many young people entered this trade. Over time, fishers learn in great detail the behavior of the river, its hydrological periods, its hydrography, the strength of its currents, and its geographic accidents, such as rapids (*correntadas)*, watering places (*regadales*), beaches, shallows, and backwaters. Fishers also learn the seasonal behavior and diurnal and nocturnal cycles of giant catfish, and with practice over time and with persistent advice from experienced fishers, they learn about baits, capturing techniques, and the most successful capturing locations. Fishers are the first ones to check the stomach contents of giant catfish to determine which fish-prey they were consuming at the moment of capture and then look for these species as bait. Over a lifetime, angler fishers accumulate an enormous amount of information about prey–predator relationships and fish behavior.

Throughout his life, Trujillo accumulated expert fishing knowledge that enabled him to effectively gather information about the feeding relationships of each of the giant catfish species. Accompanied by scientific methods and with a simple spreadsheet, he recorded his knowledge about the diets of each of the species and generated extensive lists of prey. Then he consulted with fellow fishers to expand these lists. The expanded prey lists were then used as the base to organize additional information in new columns, such as classification of species as bait or natural prey, the hydrological period in which the relationship occurs, and notes on whether the predation occurs on the Caquetá River or in its tributaries, providing information on how far upstream giant catfish can swim.

The resulting list of prey for the piraiba reached 93 species, whereas scientific research had only been able to identify 17 prey species, i.e., local knowledge exceeded scientific knowledge five times over. The list of species compiled by Luis Angel Trujillo was later complemented by his descriptions of the methods of capture, the moment in the river's hydrological cycle, the behavior of each prey, and other fish stories he learned from Indigenous peoples. This magnificent material, compiled over 20 years, was edited for publication in collaboration with Confucio Hernández Makuritofe, an Indigenous Uitoto expert in the art of illustration. Under the direction of Trujillo and his family, Makuritofe drew, one by one, the ecological relationships present in the world of water with impressive mastery and detail.

The result was published in a book, *Piraiba: Ecología Ilustrada del Gran Bagre del Amazonas* (Trujillo, Rodríguez, and Hernández 2018). It is the product of extensive dialogue between local knowledge and academic knowledge in the fields of biology, systematic taxonomy, and ecology, complemented with ecological illustration. That same year, the book obtained the Alejandro Angel Escobar National Research Prize, the most important research prize in Colombia. For the first time in Colombian history, local knowledge was recognized with a prize traditionally dominated by academic scientific research. The impact of this collaborative work has also permeated public institutions, and environmental government agencies are beginning to recognize the importance of including local knowledge and community monitoring in the management of fisheries in Colombia.

References:
Agudelo Córdoba, Edwin, Yolanda Salinas Coy, Claudia Liliana Sánchez Páez, Colombia, Ministerio del Medio Ambiente, and Instituto Amazónico de Investigaciones Científicas. 2000. *Bagres de la amazonía colombiana: un recurso sin fronteras*. Bogotá, Colombia: Instituto Amazónico de Investigaciones Científicas Sinchi. Programa de Ecosistemas Acuáticos. Editorial Scripto. https://sinchi.org.co/files/publicaciones/publicaciones/pdf/Bagres%20WEB.pdf.
Rodríguez Fernández, Carlos Alberto. 1992. *Bagres, malleros y cuerderos en el bajo Río Caqueta*. 2. ed. Estudios en la Amazonia colombiana ; Studies on the Colombian Amazon, v. 2 = v. 2. Bogotá, Colombia: Tropenbos-Colombia.
Trujillo, Luis Ángel, Carlos A Rodríguez, and Confucio Hernández Makuritofe. 2018. *Piraiba: ecología ilustrada del gran bagre del Amazonas*.

Biodiversity as a form of sexual education

Country: Colombia

Summary Authors: Oscar Romualdo Román-Jitdutjaaño and Juan Álvaro Echeverri

Oscar Román-Jitdutjaaño 'Enokakuiodo', a Murui nɨpode elder, and anthropologist Juan Alvaro Echeverri have collaborated on research, and work on salt since 1995. The Murui word *ɨaizaɨ* (salt) refers to alkaline salts of vegetable origin, which are used by the Murui and other neighboring groups as a mixture for tobacco paste (*yera ambil*). However, in a symbolic and spiritual sense, the concept of *ɨaizaɨ* refers to the fertilizing potency present in all living beings and is the basis of the formation of human beings and the management of their relationships (Román-Jitdutjaaño *et al.* 2020).

This was an intercultural work, meaning not so much the combination of different approaches—Indigenous and scientific—on the same object (salt), but rather the recognition of the same (human) condition through the construction of different objects: an object of the positive sciences, salt; and an object of Indigenous knowledge, the human body. An intercultural project is above all the construction of a social relationship between people with different capacities and knowledge, where an exchange of substances and services is established to achieve some common goal. This relationship is precisely the object of Indigenous knowledge; substances and services—food, tobacco, money, tools—are the salt of the matter. This relationship is comparable to the sexual relationship between a couple, where the exchange of substances leads to fertility, the main focus of this knowledge.

From the perspective of science, the subject of our common research is the salt; from the Indigenous perspective, what matters is the salt of the matter: the project, seen as a human relationship. What interests us is the latter. We want to show how the study of the human condition is carried out through a reading of the plant species used to extract plant salts, which are conceived as coming from the body of the Creator and as an image of the human body.

Plant species conspicuously show bodily processes that are hidden from perception. This reading of natural entities is intended to guide moral behavior and to develop a healthy, sociable, and fertile human body. Unlike the knowledge of objective and empirical sciences, Indigenous knowledge of biodiversity can be conceived as sexual education, understood as "knowledge of the body" (*abɨna onode*); that is, the control and management of bodily humors, affections, and capacities, in order to achieve fertility.

We said above that our concept of "interculturality" goes beyond the combination of different approaches (Indigenous and scientific) on the same object. In the western vision, plant salt (and its different associations) is an object and its different interpretations a matter of cultural difference. From Indigenous knowledge, on the other hand, the fact that each culture is apparently talking about a different object (or objects) is irrelevant, insofar as the objects share a common condition: humanity. Indigenous knowledge about plants is a device for understanding the dangers and risks ("salt-diseases") of the relationship involved in any political or scientific engagement, i.e., sexual education.

There is much to learn from Indigenous and local communities that directly depend on, spiritually value, and fight for their biodiverse ecosystems. These peoples not only value biodiversity for its utility, but also and primarily because these natural entities, objects, and species are their very body.

In 1995, at the very beginning of our study of the salts, Enokakuiodo wrote a text in the Murui language, entitled *Nabairiya* (Agreement), in which he made explicit the objective of our common effort. We translate some lines from it, which may give us an idea of the salt of the matter (Román-Jitdutjaaño *et al.* 2020, 1339):

fitoɨ raidora jenoyena	Seeking fruitfulness in a dangerous frontier.
yɨzidɨno dujuna jenua	Seeking the formation of life.
kaɨe daanori onoiyena feeiredɨno taɨjɨe	To know together what is ours, is a difficult job.
jaɨkɨna maɨrɨe jɨaɨe jibibɨrɨdɨno	A direct power to other *mambeaderos*.

menade nɨɨ ɨairoji jɨaɨ nairaɨ	Two oceans, two peoples.
daaje Moniya nagɨma Kamani nagɨma	Europe and America.
fakadoga uai komɨnɨdɨkaɨ uai	Each speaks with its own voice.
kɨona onoga komɨnɨ iyano nagɨma	Each one lives according to its origin.
jɨrui uai nɨbaɨde onoñenia iia yote jɨruiñede	Sexuality however is the same; it is dangerous, one must know.
yoneraɨngo nɨɨ yoneraɨma daɨit-adɨma onoiga	The sex education teacher [biodiversity] is the one who knows, for she has already experienced everything.

References
Román-Jitdutjaaño, Oscar, Simón Román, y Juan Alvaro Echeverri. 2020. *Ɨairue nagɨni, Aiñɨko urukɨ nagɨni, Aiñɨra urukɨ nagɨni: Halógeno-Halófita, Sal de vida*. Leticia: Universidad Nacional de Colombia, Sede Amazonia, Instituto Amazónico de Investigaciones Imani. https://repositorio.unal.edu.co/handle/unal/77785.

Training Indigenous Environmental Agents in the Southern Brazilian Amazon

Country: Brazil
Summary Author: Ney José Brito Maciel (PPI/IEB)

The Continous Training Program for Indigenous Environmental Agents in the south of the Amazon is the result of a consolidated partnership between the Indigenous Peoples Program (PPI) of the Institute of Education of Brazil (IEB) and the Parintintin, Jiahui, Tenharim, and Apurinã Indigenous peoples, with their respective representative organizations. In 2020, 73 Indigenous Environmental Agents (AAIs) participated in this training program, which seeks to reflect on concepts, practices, techniques, and technologies to support sustainable development and environmental security. Ultimately, the training program aims to increase the technical and political capabilities of Indigenous participants for facing a range of socio-environmental challenges that affect their territories.

The courses provide complementary spaces for dialogue and debate between diverse Indigenous and non-Indigenous concepts and practices, with the premise of developing a more equitable and balanced dialogue between Indigenous and non-Indigenous knowledge, particularly mainstream scientific knowledge. Courses aim to build a productive collaborative relationship between communities that have distinct worldviews, and yet share the same planet. The result is new ideas, new commitments, and new co-produced intercultural practices.

An essential part of this continuing education program is to carry out activities "on the ground" in the villages where AAIs live. These activities include natural resource management and conservation, political articulation with their communities, surveillance and inspection actions, research, mapping, and production of GIS maps, surveys, diagnoses, and inventories of natural resources and/or agro-forestry, as well as other interventions based on the opinions and demands gathered directly from the residents.

The training, followed by continued activity by AAIs in their villages and in political spaces, is part of a broader process that involves many other Indigenous peoples in Brazil, and is recognized as one of the most important components in the field of Brazilian environmental indigenism. This recognition stems from the very effectiveness and practical results that they demonstrate in the effective environmental and territorial management of their territories. In this sense, AAIs are considered central social actors in the effort to place Indigenous peoples on another level, where they are no longer attributed the role of victims or obstacles to national development, but rather as collectives whose actions are essential for the environmental protection of Brazilian biomes and for authentic sustainable development.

Financial support for this continuing education comes from various sources, almost always from various international cooperation projects. Specifically, to support the training of the 73 AAI mentioned here, resources are being provided by USAID, which supports the Our Land Project: Support for Territorial Management in southern Amazonas; and resources from the Amazon Fund, which supports the Sulam Indigenous Project: Indigenous Territorial Management in southern Amazonas. Both are aimed at improving and enhancing the environmental and territorial management of the Indigenous lands of the above mentioned peoples.

To learn more about these and other partnerships between the PPI/IEB and the Indigenous peoples of the southern Amazon, go to https://iieb.org.br/projetos-e-programas/povos-indigenas-2 or visit https://www.youtube.com/c/canaldoieb/videos.

Citizen science as a tool for fisheries monitoring using the Ictio App in the Madeira River Basin

Country: Brazil
Summary Author: Carolina R C Doria

Continental fisheries are less regulated in developing countries than in other regions of the world, and fishing statistics on fish landings are underrepresented or non-existent. The lack of robust data in Brazil is recognized as a threat to the management and conservation of stocks. A large and diverse population of small-scale fisherfolk undertake fishing activities in freshwater ecosystems, often in remote, undefined places. Catches are seasonal and species composition highly variable. Most catches do not enter a formal market but go directly to domestic consumption. These factors make it even more difficult to monitor fisheries and assess stocks.

This situation is even more aggravated in the state of Rondônia because the only fisheries monitoring in the region is done by hydroelectric dam construction and operation companies. Therefore, government fisheries managers can only access data with difficulty, and access is essentially impossible for fishers. As a result, these actors cannot participate in fisheries assessments and managing fisheries in the region is very difficult.

Between July and December 2018, the ECOPORÉ non-governmental organization and the Ichthyology and Fisheries Laboratory of the Federal University of Rondônia tested the Ictio application as a tool to solve gaps in small-scale fisheries monitoring. This was part of an Amazon-wide collaborative project that supported training of a technician and a local intern, and the exchange of experiences with other projects across the Basin.

The project encouraged the participation of fishers in data collection and interpretation to answer their own questions about fishing. Fishers were invited through community meetings and also at fish landing sites. Project team members and participating fishers communicated via community meetings and Whatsapp groups and discussed the situation of exploited fishing resources; the impacts of hydroelectric dams on fish, particularly on migratory fish; and other topics of interest to fishers.

Field testing results demonstrated that it is possible to use smartphones to collect data on small-scale fishing landings. Using citizen science protocols and the Ictio App on smartphones, fishers collected data on small-scale fish landings. At the same time, community members were empowered to monitor and co-manage fisheries, uniting formal and traditional governance. This is particularly important in the Madeira Basin, given the recent implementation of two hydroelectric plants in the system, and the numerous problems caused by fishers' lack of access to data collected by hydroelectric companies, inhibiting their participation in decision-making.

As long as fisherfolk have access to the internet through smartphones, the Ictio App can be a powerful tool, allowing greater ownership when participating in data collection and also the creation of a support network between users.

The network created between the technical team and the fishermen makes it possible to continue the project by encouraging fishermen to keep daily records. In addition, the Citizen Science for the Amazon Network that emerged in this process seeks to replicate it throughout the entire Amazon Basin. To this end, next steps involve disseminating the results obtained so far and raising awareness about the Ictio App and the Network among as many fisherfolk as possible. We expect that the number of (sporting and professional) fisherfolk that use the application will increase in the coming years and that the information generated will be used to increase understanding of fisheries stocks so that fisherfolk can propose management and mitigation measures to address impacts of the hydroelectric dams and overfishing on fisheries in the Madeira Basin. For more information see https://ecopore.org.br/novo/o-que-os-cientistas-cidadaos-estao-registrando-no-ictio-neste-2020.

The Citizen Science for the Amazon Network: An Amazon-wide multi-scale collaboration to understand large-scale fish migrations

Countries: Bolivia, Brazil, Colombia, Ecuador, Peru
Summary autor: Mariana Varese

The Citizen Science for the Amazon Network is a knowledge network that seeks to create and share knowledge in an accessible, trustworthy, and timely way, with the ultimate goal of informing management and policy decisions at scale in the Amazon Basin. As of April 2021, the network included over 30 partners of different backgrounds from 7 different countries, all working on Amazon freshwater systems from their own perspective and interests. Partners have their own area of influence and lead collaborations with 70+ citizen scientist groups; thus, the Citizen Science for the Amazon Network is in fact a regional network of local networks (Figure 1).

Figure 33.A2.1 As of September 2021, there are over 30 partners of the Citizen Science for the Amazon Network, including universities, research institutes, non-governmental organizations, grassroots organizations, and individuals from 7 different countries, including Bolivia, Brazil, Colombia, Ecuador, France, Peru, and the United States of America.

The Citizen Science for the Amazon Network focuses on Amazon freshwater systems and started with migratory fish because fish are sentinels of the Basin's connectivity, critical for the livelihoods of rural and urban people, and connect people with the ecosystem (see following Figure). In the Amazon's extremely diverse and complex context, network partners create connections without forcing partners to meet standards or protocols that may become a barriers for participating organizations and IPLCs. First, through a collaborative process that started in 2017 and continues today, partners jointly defined a common question general enough to gather multiple stakeholders, and able to weave in other questions at smaller scales. *Where and when do fish migrate in the Amazon Basin and what environmental factors influence these migrations?*

Having a clear common framework, the Network also builds from the knowledge, capacities, and experience of partners and others. Partners design, test, and adapt innovative solutions catered to the Amazon context, constantly learning in this process. Over time, partners have agreed on guiding principles, varia-

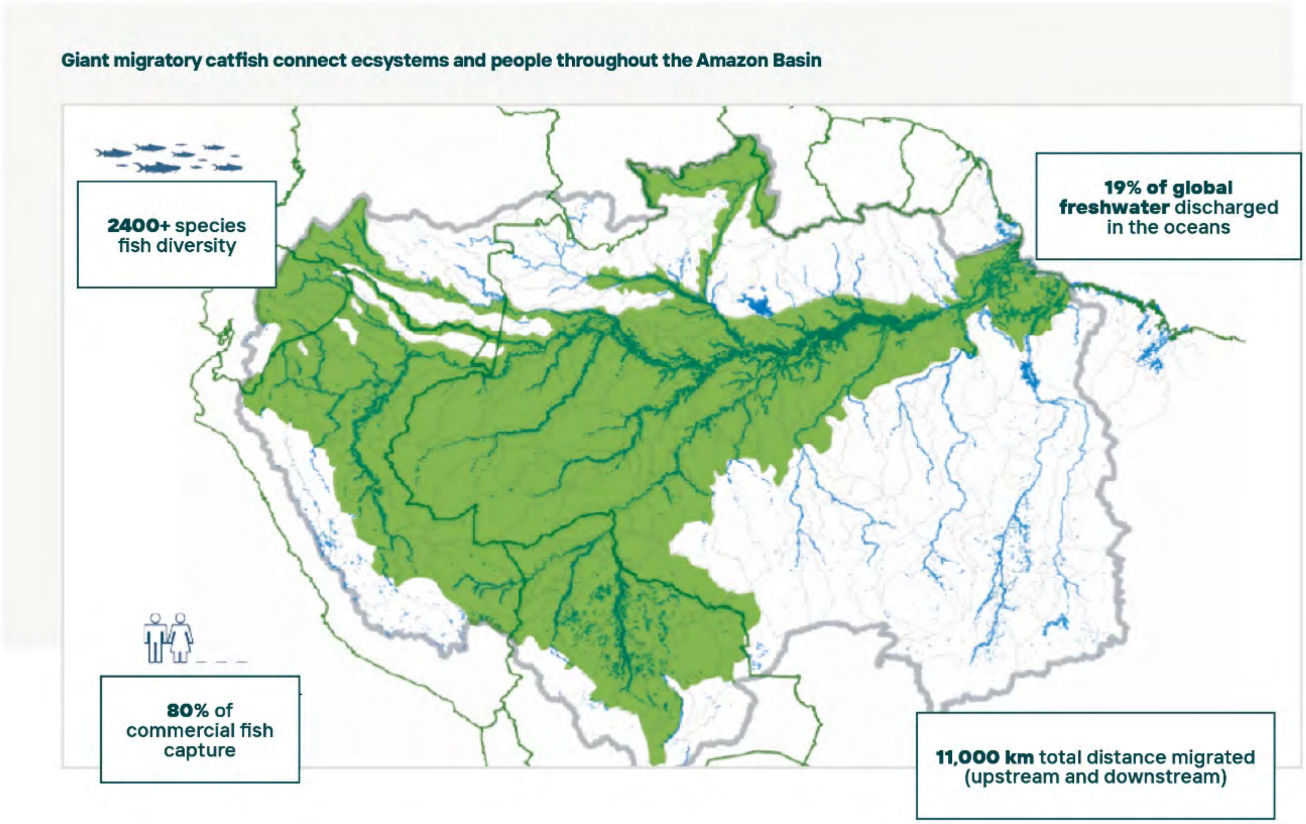


Figure 33.A2.2 Green represents the areas important for continental and large-scale migratory fish life cycles. © WCS, based on Venticinque et al. (2016), Goulding et al. (2019).

bles, protocols, free prior informed consent, terms of use, credit, and protection of privacy guidelines. These are periodically reviewed, assessed, and adjusted with an adaptive management approach.

A major achievement is Ictio.org, a shared database and app to generate, manage, and share data on observations of the most important migratory and food fish in the Amazon. Ictio.org was developed by the Cornell Lab of Ornithology in collaboration with Wildlife Conservation Society and Network partners. As of June 2021, Ictio's shared database included over 55,000 fish observations in 75% of the total 198 Amazon Level 4 sub-basins (as per Venticinque et al. 2016) (Figure 3). A lot more data is needed to make robust inferences at scale, and both Ictio and the Network are prepared to foster such large-scale, multi-stakeholder, multi-scale collaborations. To address challenges associated with the high-level of diversity and complexity of fisheries in the Amazon Basin, Ictio embraces diverse sources of data on fish observations (uploading data to the app, recording in notebooks, government data, researcher-based monitoring frameworks), and partners follow careful procedures to ensure proposed activities are presented, consulted, co-designed, and implemented with participating citizens, IPLCs, and organizations in a collaborative way, where objectives and decisions about access and use of the generated information are transparently and horizontally agreed upon.

Data is then made open to the public and shared through a three-tiered system that seeks to protect the privacy and rights of participating citizens and their communities or organizations (especially IPLCs),

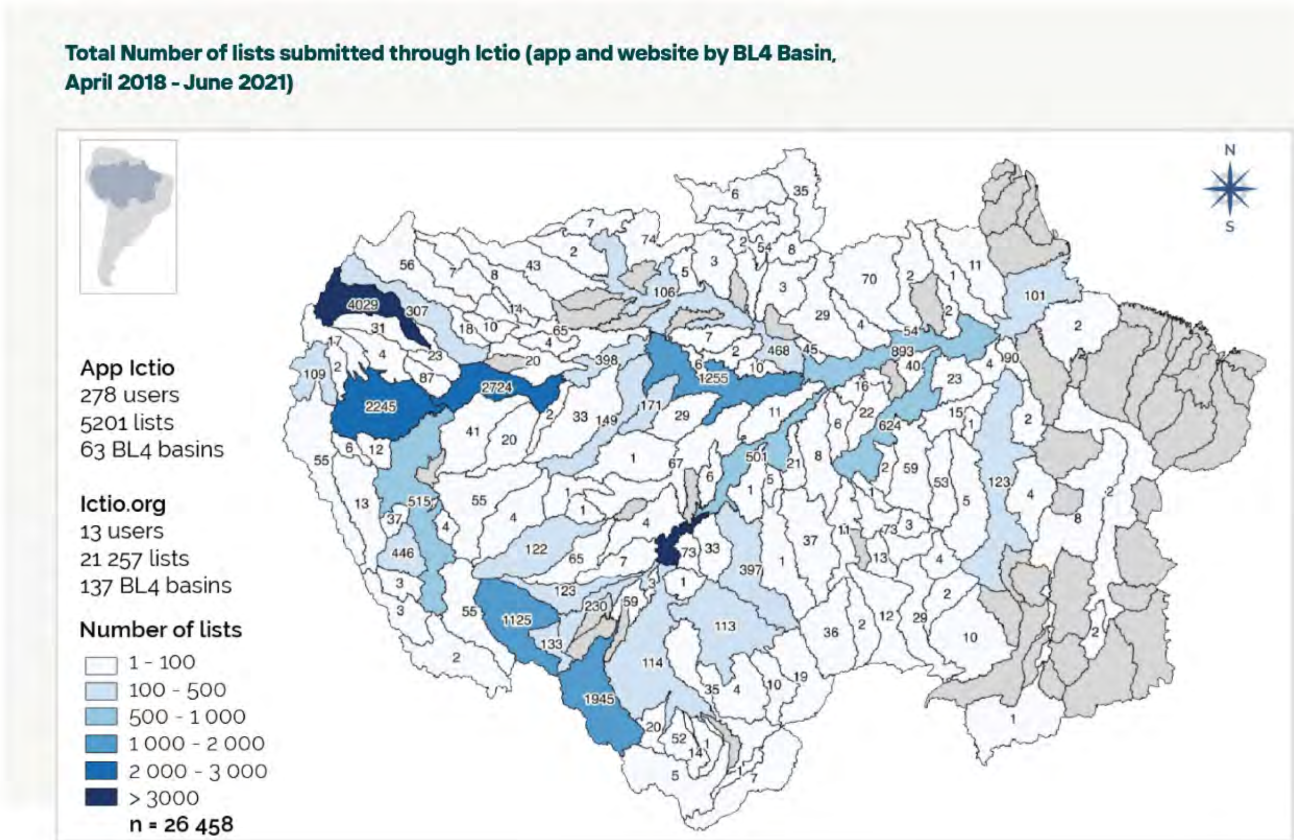


Figure 33.A2.3 Between April 2018 and June 2021, a total of 26,458 lists (observation events) were uploaded to the Ictio shared database, through the Ictio App and/or the online platform (ictio.org). These lists represent a total of 57,372 observations of 126 fish taxa (including 12 giant migratory catfish species), across 149 BL4 sub-basins of the Amazon that represent 75% of the 198 BL4 level sub-basins (as per basin classification by Venticinque et al. 2016).

while following the principles of open science and open access (see OCDKN 2015). Individual citizen scientists (users may be a person, a community, or a fisherfolk association) have complete access to the full data set they generate. Network partners have access to a data set that does not include personal identifiers but includes precise location names or coordinates. This is important for partners to address locally-relevant questions (e.g., at the level of a watershed or river tract). Finally, data is available to the public via the Ictio.org website, but this dataset does not include personal identifiers such as names and contact information, nor precise location names or coordinates. Instead, this dataset only includes the Basin Level 4 watershed for location (between 10,000 and 100,000 km^2 as per Venticinque *et al.* 2016). This system enables citizens, IPLC organizations, managers, and researchers to use the data for multiple purposes at different scales—from recording individual fishing/selling statistics, to informing community-based fisheries management plans, to understanding impacts of infrastructure projects such as dams on fish migrations, to learning about continental-level giant catfish migratory patterns.

The Citizen Science for the Amazon Network still faces important challenges on its quest to increase our collective understanding of the connectivity and integrity of freshwater systems, but a strong foundation of transparency, collaboration, adaptive management, and innovation has been laid out (see also World

Bank 2021, p. 297). In the coming years, Network partners will focus on increasing the fish database, connecting it with other similar or complementary efforts, and gathering best practices and lessons to continue fostering public participation in knowledge generation and sharing to inform decisions and policies across the Amazon. All this, while managing potential tensions associated with the Network's commitment to scale (this is what brings partners together), while embracing diversity of sources of knowledge (especially ILK), and respect and enforcement of the fundamental rights of IPLCs. For instance, reaching Basin-wide scale requires some level of homogenization, while community-based monitoring or science generally involves multiple forms of knowledge, associated with specific environmental, social, and cultural contexts. This diversity makes it difficult to agree on common criteria, parameters, and thresholds for aggregation. Also, it sometimes forces us to negotiate among conflicting views of the world. Authorship, intellectual property rights, and appropriate credit given to non-mainstream scientists continues to be an unresolved challenge, although important progress has been made in recent years.

As Network partners deal with these tensions and address these challenges, a fundamental guideline is to follow the precautionary principle and that local partners take the lead on identifying together with citizen scientists (e.g,. fisherfolk associations, Indigenous communities, or students) what local questions to answer, how to analyze and use the data, if and how to share information, what decisions to inform, and what audiences to target.

The rapidly evolving fields of citizen science, open science, and open access offer globally-important lessons and best practices that can contribute to sustainable pathways for the Amazon, in a way that places its peoples at the center of conversations. The Citizen Science for the Amazon Network provides a model of an Amazon-Basin-wide network that connects diverse and distributed communities to generate and share knowledge and co-create solutions through a decentralized, transparent, and innovative governance model. For more information visit https://www.amazoniacienciaciudadana.org/english/ .

References:

World Bank (Washington, District of Columbia), ed. 2021. *World Development Report 2021: Data for Better Lives*. World Development Report. Washington: World Bank. https://wdr2021.worldbank.org/the-report/#download

Collaborative Knowledge Production and Coalition Building for Conservation Action through Rapid Biological and Social Inventories

Countries: Andean Amazon (Bolivia, Colombia, Ecuador and Peru)
Summary authors: Christopher Jarrett and Diana Alvira Reyes

Since 1999, the Field Museum has led 31 rapid biological and social inventories in areas of high biodiversity and uniqueness, and 24 of these have been conducted in the Amazon: 14 in Peru, 3 in Bolivia, 3 in Ecuador, 2 in Colombia, and 2 binational (Ecuador–Peru and Peru–Colombia). Rapid inventories leverage the Field Museum's scientific expertise and collections of over 40 million specimens to collaboratively produce knowledge that supports conservation action. Our vision of conservation is one in which environmental health is intimately linked with local peoples' well-being, so we design inventories to bring together diverse groups and with the shared goal of sustained stewardship of these unique and important landscapes (Wali et al. 2017).

Rapid Inventories

	PROTECTED	HECTÁREAS	ACRES
01	Bolivia: Tahuamanu	1,427,400	3,527,105
02	Perú: Cordillera Azul	1,353,190	3,343,732
03	Ecuador: Cofán-Bermejo	55,451	137,019
06	Bolivia: Bruno Racua	74,054	182,991
11	Perú: Tamshiyacu-Tahuayo	322,979	798,098
12	Perú: Ampiyacu-Apayacu	433,099	1,070,211
15	Perú: Megantoni	216,005	533,748
16	Perú: Matsés	420,635	1,039,413
17	Perú: Sierra del Divisor	1,478,311	3,652,906
18	Perú: Nanay-Pintayacu-Chambira	953,001	2,354,916
20	Perú: Güeppí-Sekime	203,629	503,177
20	Perú: Huimeki	141,234	348,998
20	Perú: Airo Pai	247,888	612,544
21	Ecuador: Territorio Ancestral Cofan	30,700	75,861
21	Ecuador: Cofanes-Chingual	89,272	220,596
22	Perú: Maijuna-Kichwa	391,040	996,280
23	Perú: Yaguas	868,927	2,147,118
	Total Protegido / Protected	8,706,815	21,544,713

	REINFORCED	HECTÁREAS	ACRES
04	China: Yunnan	405,549	1,002,133
07	Cuba: Zapata	432,000	1,067,495
08	Cuba: Cubitas	35,810	88,488
09	Cuba: Pico Mogote	14,900	36,819
10	Cuba: Siboney-Juticí	2,075	5,127
13	Cuba: Bayamesa	24,100	59,552
14	Cuba: Humboldt	70,680	174,654
20	Ecuador: Cuyabeno	603,380	1,490,984
24	Peru: Kampankis (Santiago-Comaina)	398,449	984,590
31	Colombia: Reserva Forestal Tarapacá	425,471	1,051,362
31	Colombia: Amacayacu	293,500	725,254
31	Colombia: Rios Cotuhé y Putumayo	255,146	630,479
	Total Fortalecido / Reinforced	2,961,060	7,316,937

	PROPOSED	HECTÁREAS	ACRES
05	Bolivia: Madre de Dios	51,112	126,298
06	Bolivia: Federico Román	202,342	499,987
11	Perú: Yavarí	777,021	1,920,019
19	Ecuador: Dureno	9,469	23,398
23,31	Perú: Bajo Putumayo	347,699	859,164
25	Perú: Ere-Campuya-Algodón	900,172	2,224,325
26	Perú: Cordillera Escalera-Loreto	130,925	323,516
27	Perú: Tapiche-Blanco	308,463	762,212
28	Perú: Medio Putumayo-Algodón	416,600	1,029,419
29	Colombia: Lindosa, Capricho, Cerritos	54,000	133,434
30	Colombia: Bajo Caguán-Caquetá	779,857	1,927,027
	Total Propuesto / Proposed	3,977,660	9,828,798

TOTAL	HECTÁREAS	ACRES
Protegido / Protected	8,706,815	21,544,713
Fortalecido / Reinforced	2,961,060	7,316,937
Propuesto / Proposed	3,977,660	9,828,798
TOTAL HECTÁREAS / ACRES	15,645,535	38,660,117

Figure 33.A2.4. Locations of rapid inventories conducted in the Amazon

While the whole inventory process typically lasts a year or more, the main fieldwork portion is completed within a few short weeks. A multidisciplinary team of local, national, and international experts—biologists, social scientists, and representatives from civil society and government—work with local people to learn as much as possible about a landscape and what is needed to protect it. For the biological portion of the inventory, the team surveys plants, fish, amphibians, reptiles, birds, and mammals—organisms that indicate habitat type and condition and that can be surveyed quickly and accurately. They identify species, natural resources, and landscape features with high conservation value (at global, national, or local scales), assess their status, and document threats to these natural assets. For the social portion of the inventory, the team uses a variety of social science methods—participant observation, interviews, focus groups, participatory mapping, and others—to quickly identify the assets and aspirations of local people, as well as the challenges they face. Such knowledge informs recommendations for conservation action (Pitman et al. 2021) to ensure that they align with local peoples' strengths and visions for their quality of life.

As soon as fieldwork is complete, the team presents preliminary findings to local people and in-country decision-makers. Then, practical recommendations for long-term conservation are developed, which often include establishing a new protected area and strengthening environmental governance in the region by mitigating threats and supporting sustainable natural resource use. In the months and years following the inventory, we share the recommendations, reports, and other inventory products with decision-makers, who in turn take action. We also produce a written report that we return to local people and make available in digital form for free online (http://fm2.fieldmuseum.org/rbi/results.asp).

Rapid inventories are participatory knowledge production processes. During fieldwork, in-country and international scientists collaborate with local people to understand the environments surveyed through a synthesis of scientific and local knowledge. The process makes visible the intimate understanding local populations have of the landscapes they call home and the ways in which their long-term stewardship has conserved these places over time. At the same time, it provides local people access to scientific knowledge that allows them to better manage their resources and protect their territories from threats such as deforestation and contamination from mineral extraction, which are typically driven by outsiders.

Rapid inventories are also structured to create diverse coalitions that drive conservation action. Since the first rapid inventory, we have worked with thousands of people, hundreds of local communities, dozens of in-country organizations, and more than 20 different Indigenous peoples. We deliberately build a consensus vision for conservation across a wide cross-section of stakeholders, while acknowledging and respecting the differences among the actors involved. The vision explicitly puts local people at the forefront to ensure that conservation actions are just, equitable, and sustainable. The rapid inventory process has allowed local people to gain greater recognition of, and formalize, their sustainable management practices. It has also helped in-country government agencies better understand the sociocultural, political, and biological contexts in the areas they are tasked with protecting. This consensus-based approach ensures that the vision is seen as broadly legitimate and thus attractive to decision-makers. It also ensures more effective protection by incorporating the knowledge and needs of local people into conservation.

Finally, rapid inventories have laid the groundwork for new participatory knowledge construction and data management tools. For instance, after inventories are complete, we develop field guides based on the observations and collections during fieldwork, and these guides are subsequently made available to in-country researchers and local communities for educational and research purposes (See Field Guides here: https://fieldguides.fieldmuseum.org). We have also recently partnered with Yale University's Map of Life project (https://mol.org) to develop "Biodiversity Dashboards" (https://mol.org/places), an online tool for easily accessing biodiversity data. The Biodiversity Dashboards provide regularly updated species lists by country, territorial designation (province, region, or department), protected area, watershed, or Indigenous territory. This information is currently available for Colombia, Ecuador, and Peru, and we hope to expand to other countries and regions in the future.

References:

N. C. A. Pitman, C. F. Vriesendorp, D. Alvira Reyes, ... J. A. Maldonado Ocampo, I. Mesones Acuy, Applied science facilitates the large-scale expansion of protected areas in an Amazonian hot spot. Sci. Adv. 7, eabe2998 (2021).

Wali, Alaka, Diana Alvira, Paula Tallman, Ashwin Ravikumar, and Miguel Macedo. 2017. "A New Approach to Conservation: Using Community Empowerment for Sustainable Well-Being." *Ecology and Society* 22 (4). https://doi.org/10.5751/ES-09598-220406.

Amazon Assessment Report 2021

Chapter 34

Boosting relations between the Amazon forest and its globalizing cities

Rio Negro na região da vila do Cacau Pirêra, em Iranduba, Amazonas (Foto: Raphael Alves/Amazônia Real)

INDEX

GRAPHICAL ABSTRACT **2**

KEY MESSAGES **3**

ABSTRACT **3**

34.1 INTRODUCTION **4**

34.1.1 Rural-urban (dis)connection today 5
34.1.2 The urban forest (should turn into forest cities?) 7

34.2 ADDRESSING THE (DIS)CONNECTIONS **9**

34.3 PHYSICAL RURAL–URBAN (DIS)CONNECTIONS IN THE AMAZON **9**

34.4 FORMAL AND INFORMAL ECONOMY **10**

34.5 FOOD SECURITY **10**

34.6 HEALTH SYSTEMS AND DISEASES **11**

34.7 KNOWLEDGE INFRASTRUCTURE AND HUMAN CAPITAL **12**

34.8 GREEN INFRASTRUCTURE AS NATURE-BASED SOLUTIONS **13**

34.9 INFORMATION (SMART CITIES, SMART FORESTS) **16**

34.10 CONNECTING CULTURALLY WITH THE FOREST **16**

34.10.1 Are the Amazonian cities culturally (dis)connected from the surrounding forest? 17

34.11 PRACTITIONER REFLECTIONS ON RECONNECTIONS **18**

.... **30**

34.14 REFERENCES **31**

Graphical Abstract

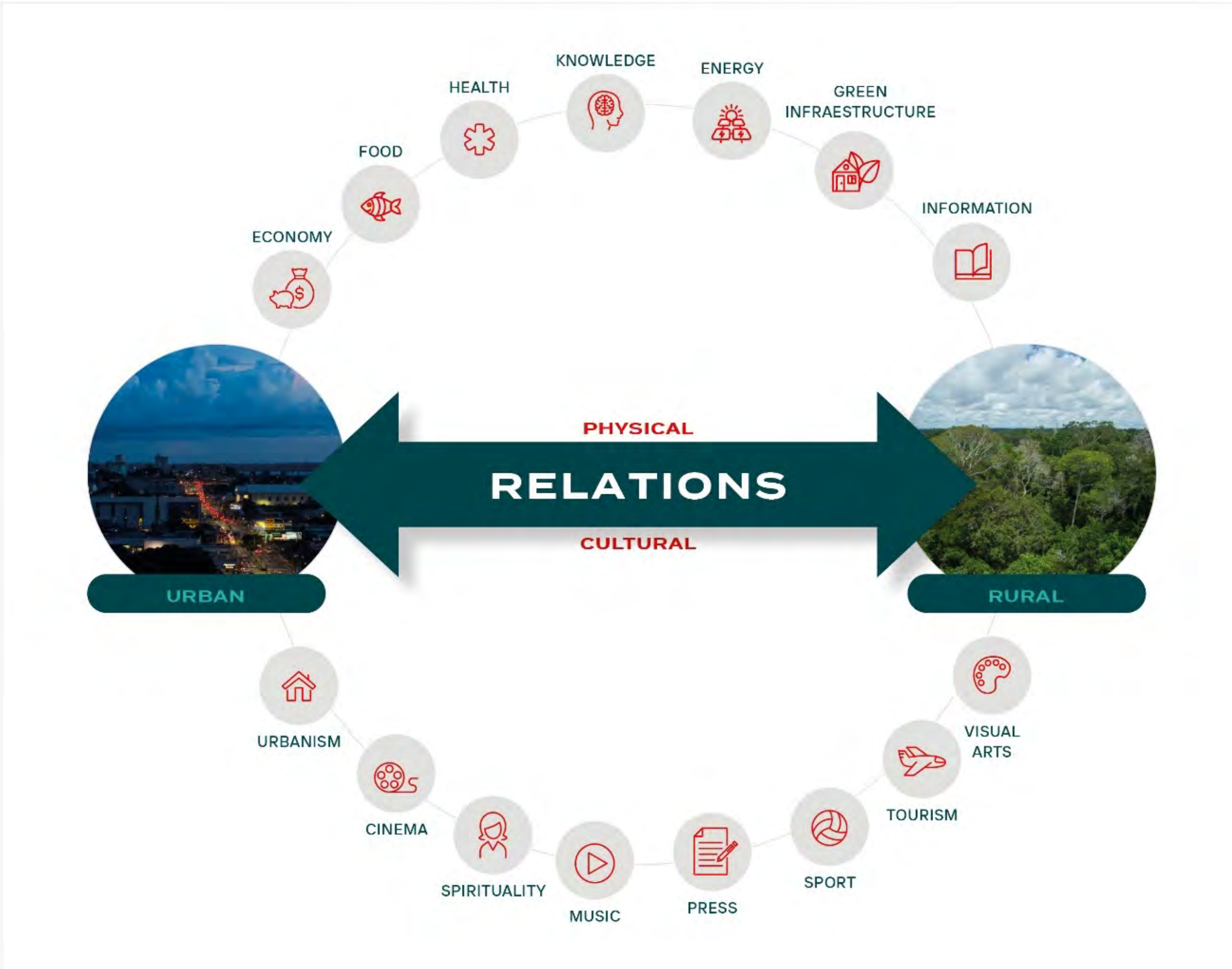


Figure 34.A Graphical Abstract

Boosting Relations between the Amazon Forest and Globalizing Cities

David M. Lapola [a]; Belen Páez [b]*, Sandra Costa[c], Roberto Donato da Silva Júnior[a], Daniela Peluso[d], Paulo Moutinho[e], Nathália Nascimento[f], Maíra C.G. Padgurschi[a], Denilson Baniwa[g], Sônia Bridi[h], Nadino Calapucha[i], Zienhe Castro[j], Fander Falconí[k], James Junior[l], Mapulu Kamayurá[m], Eduardo Kohn[n], Anderson Mattos[o], Pedro M. Nassar[p], Laurent Troost[q], Manari Ushigua[r], Robert Wallace[s], Marko Zangas[t]*

Key Messages

- The myths of civility versus savagery and of the inexhaustibility of Amazon natural resources, as well as the flattening of increasingly globalized cultures all cause physical and cultural dis- or misconnections between urban and rural environments in the Amazon.
- Physical dis- or misconnections, such as those related to local economies, food security, healthcare, schooling, and green urban infrastructure, could all be improved with well-planned participatory actions beneficial to both rural and urban dwellers. Some of these actions are: effectively involving rural populations in decision-making processes, fostering small-scale food production in peri-urban areas, subsidizing the long-term residence of healthcare professionals and infrastructure in small cities, the establishment of education hubs strategically located in rural areas, increasing urban green infrastructure, and operationalizing the concept of "smart cities—smart forests".
- A cultural (re)connection of urban-dwellers with the forest should be fostered with concerted interventions in various sectors such as tourism, sports, and visual arts as a way to win people's hearts and minds about the forest. Existing well-established rural–urban bonds such as food habits and traditional festivities can serve as good starting points to bring this cultural relation to a higher level.
- This refoundation of the Amazon culture in the context of urbanized populations is a stake not only for policy makers or traditional populations but to society in general, including urban- and forest-dwellers.

Abstract

The myth of civility versus savagery, the flattening of increasingly globalized urban cultures, among several other factors, have historically contributed to a misconnection between cities and rural (forest) areas

[a] Universidade Estadual de Campinas - UNICAMP, Campinas, São Paulo, Brazil. dmlapola@unicamp.br
[b] Fundación Pachamama Mayurah, El Potrero vía Lumbisí, Alfonso Lamiña, Quito 170157, Ecuador. belenpaez74@gmail.com
[c] University of Paraíba Valley. (UNIVAP), Av. Shishima Hifumi 2911, Urbanova, São José Dos Campos SP, Brazil.
[d] University of Kent, 100 New Dover Road, Canterbury, Kent CT3 1PQ, UK.
[e] Amazon Environmental Research Institute (IPAM), Av. Nazaré 669, Centro, Belém PA, Brazil.
[f] Universidade Federal do Espírito Santo - UFES, Instituto de Estudos Climáticos, Vitória, Espírito Santo, Brazil.
[g] Baniwa Community, Niterói RJ, Brazil.
[h] Grupo Globo, Rua Lopes Quintas, 303, Jardim Botânico, Rio de Janeiro, RJ, Brazil.
[i] Coordinator of Indigenous Organizations of the Amazon River Basin (COICA), https://coica.org.ec, Ecuador.
[j] ZFilmes Cinema & Multimidia, Travessa São Pedro 566 sala 504, Batista Campos, Belém PA, Brazil.
[k] Facultad Latinoamericana de Ciencias Sociales (FLACSO), Calle La Pradera E7-174 y Av. Diego de Almagro, Quito, Ecuador.
[l] To Goal Sports Ventures Gestão Esportiva, Eireli, Rua Salvador 120, Adrianopolis, Manaus AM, Brazil.
[m] Indigenous People of Xingu, Brazil
[n] McGill University, 845 Sherbrooke Street W, Montreal Quebec H3A 0G4, Canada.
[o] Foundation for Amazon Sustainability (FAS), Rua Alvaro Braga 351, Parque Dez de Novembro, Manaus AM, Brazil
[p] Instituto de Desenvolvimento Sustentável Mamirauá, Estrada do Bexiga 2584, Tefé, Amazonas, Brazil
[q] Manaus City Hall, Av. Brasil 2971, Compensa, Manaus AM, Brazil.
[r] Nación Sápara del Ecuador (NASE), Avenida 20 de julio Simón Bolívar, El Puyo, Ecuador.
[s] Wildlife Conservation Society, #340 Calle Gabino Villanueva, San Miguel, La Paz, Bolivia.
[t] Inside-Out – Nature, Norupvej 10, Vammen, 8830 Tjele, Denmark.

in the Amazon region. Since their establishment, Amazonian cities—where more than 60% of the region's population is located—have been predominantly used as trading posts for global commodities, which favors a poor physical and cultural relation between the cities and their surrounding forests. Urban populations permanently suffer from widespread poor healthcare, education, and sanitation conditions, whereas Indigenous people, who generally live on the outskirts of large cities, can face this urban–rural interactions in a more fluid way, inhabiting both environments more efficiently. Although the rural–urban connections are stronger and better established in small cities (e.g., Brazil nut harvesting in Pando, Bolivia), these relations are not always beneficial (e.g., many small municipalities are responsible for the highest deforestation rates in the region). Notwithstanding, much beyond physical barriers or misconnections between urban and rural forested areas, there are key cultural barriers to be overcome, especially by urban-dwellers. By providing a brief and non-authoritative review of the physical and cultural relations between rural/forest and urban areas in the Amazon, we identify several aspects for improvement such as subsidizing the long-term residence of healthcare professionals in the countryside, implementing peri-urban agricultural/extractive belts for food security in cities, increasing the permeation of forest and green spaces into Amazon urban landscapes, investing in innovation around the "smart cities–smart forests" concept, and, perhaps most important, mobilizing human, financial, and institutional resources to foster a resignification or refoundation of the cultural, spiritual, and affective bonds of urban inhabitants with the forest, supported by the forest people and their cosmovisions. We also present a set of testimonials from distinguished cultural practitioners from different cultural sectors on how they think their work can collaborate to win people's hearts and minds about the ways, beauty, benefits, good influences, and respect of/for the world's largest tropical forest.

Keywords: rural-urban fluxes, health, smart cities-smart forests, Amazon art, cultural movement, biocultural diversity

34.1 Introduction

The historical occupation and urbanization in the Amazon followed models that were created in a complex and multifaceted way, with contradictions and paradoxes (see Chapter 14). From the point of view of social, demographic, and economic forms of use and occupation, the relationship between "rural" and "urban" has been increasingly distancing itself from the idea of "agricultural frontier" (Côrtes and Silva Júnior 2021), as a very limitable and detectable process between the supposed two worlds. The concepts of "urbanized forest" (Becker 2013) or "rural cities" (Padoch *et al.* 2008) are two interconnected examples of this distancing.

Nevertheless, even with this set of established interactions, city life and values (emotional and ethical) are disconnected from the Amazonian rural and forest world (Adams *et al.* 2006) such that urban problems are seen as not interconnected with each other (Brondizio 2017). Among the various consequences of such misconnection are the exclusion of rural populations from the effective participation in the decisions that affect them and the exclusivity of the decision making by a small portion of rural people who inhabit or transit through urban centers (Le Tourneau and Bursztyn 2010); the difficulty of urban social groups in identifying and recognizing the impacts of their livelihoods on issues related to deforestation and biodiversity loss (Diegues *et al.* 1997); and, finally, the weak social engagement in processes and actions to address environmental problems directly related to rural and forested areas (Mansur *et al.* 2016).

In a broad sense, we recognize three factors that support the understanding of this ethical-evaluative disconnections between urban and rural societies in the Brazilian Amazon. Two factors are based on a historical occupation process of the region: (1) The relationship between "settlement" and "*sertão*" (hinterland) in the processes of European colonization (Farage and others 1986; Raminelli 1994; Oliveira 1998); (2) The myth of the inexhaustibility of Amazonian natural resources (Sevcenko 1996; Gadelha 2002) (Pádua, 2019). The third one is linked, more recently, to the processes of techno-scientific modernization and insertion of Amazonian cities into globalization movements: the difficulties related to the construction of subjectivity (a person's own feelings, beliefs, tastes, or opinions) in the complex social dynamics of the globalized populations (Simmel 1997; Sheller and Urry 2016).

The historical colonization process led to the disorganization of millennia-long Indigenous configurations in this macro-region and created images, symbologies, and meanings that last and significantly contribute to the usual predatory economic and social models. It also guided to the processes of urbanization that consider the forest, Indigenous socio-cultural diversity, and hydrological strength as riches to be consumed and, at the same time, "wild" spaces whose civilizing impetus should be responsible for civilizing them (Farage and others 1986; Farage 1991; Raminelli 1994; Sevcenko 1996; Oliveira 1998); [see also SPA Chapters 13 and 14].

Aligned with the widely accepted idea of a civilized and wild desert, the forests have become a gigantic sphere of abundance and affluence to be explored in an unlimited way. Since the arrival of Europeans in South America, the image of an endless nature, impossible to be exhausted by human capacities, has solidified. The difficulties inherent to the colonization process, carried out without planning, with limited human resources, through incursions such as those of *bandeirismo*, and the foundation of the settlements in the middle of the "*sertão*" have solidified this image over the 17th, 18th and 19th centuries (de Lima 2012; Cesco and de Lima 2018). In the 20th century, both modern military incursions, particularly in the Brazilian Amazon, such as Marshal Rondon's expeditions, and the plans for occupation and "defense" of the Amazon, undertaken by military governments, reinforced the image of an inexhaustible nature to be intensively explored (Bolle *et al.* 2010).

34.1.1 Rural-Urban (Dis)connection Today

The idea of occupation/*sertão*, as a reflection of the civility/savagery relationship, and the myth of inexhaustible resources persist to the present and is reflected in the development policies and in the economic and cultural forces acting in the Amazon region. Consequently, this fact contributes to the distancing and an opposing relationship between "rural area" and "city", becoming fundamental components that have prevented the spread of a culture based on caring for forests and their inhabitants. A third fundamental component for this culture of disconnection between "city" and "countryside"—the poor construction of subjectivity in a globalized world—is tied to characteristics increasingly present in contemporary societies, endowed with high mobility and located within the scope of globalized cities (Sassen and others 2002).

The concept of globalized cities, or globalized urbanization, reviewed by (Brenner and Keil 2014), is meant here as "*(...) the planetary "fabric" or "web" of urbanized spaces* (Lefebvre 2003) *(...), with well-defined urban hierarchies conditioned by supranational forces (...), through which corporations coordinate their production and investment activities.*"; It is also viewed as *"(...) an arena of contestation in which competing social forces and interests, from transnational firms, developers and corporate elites to workers, residents and social movements – struggle over issues of urban design, land use and public space."* which is nowadays far from being restricted only to the economic flows but "(...) engages with a broad range of globalized or globalizing vectors – including not only economic flows, but the crystallization of new social, cultural, political, ecological, media and diasporic networks as well." In that sense, globalized cities can also affect people's subjectivity through the flattening of local cultures to comply with a supposedly global, permanently networked, set of communal standards. All the subtleties in these definitions are applicable to the cities in the Amazon region (Fig. 34.1).

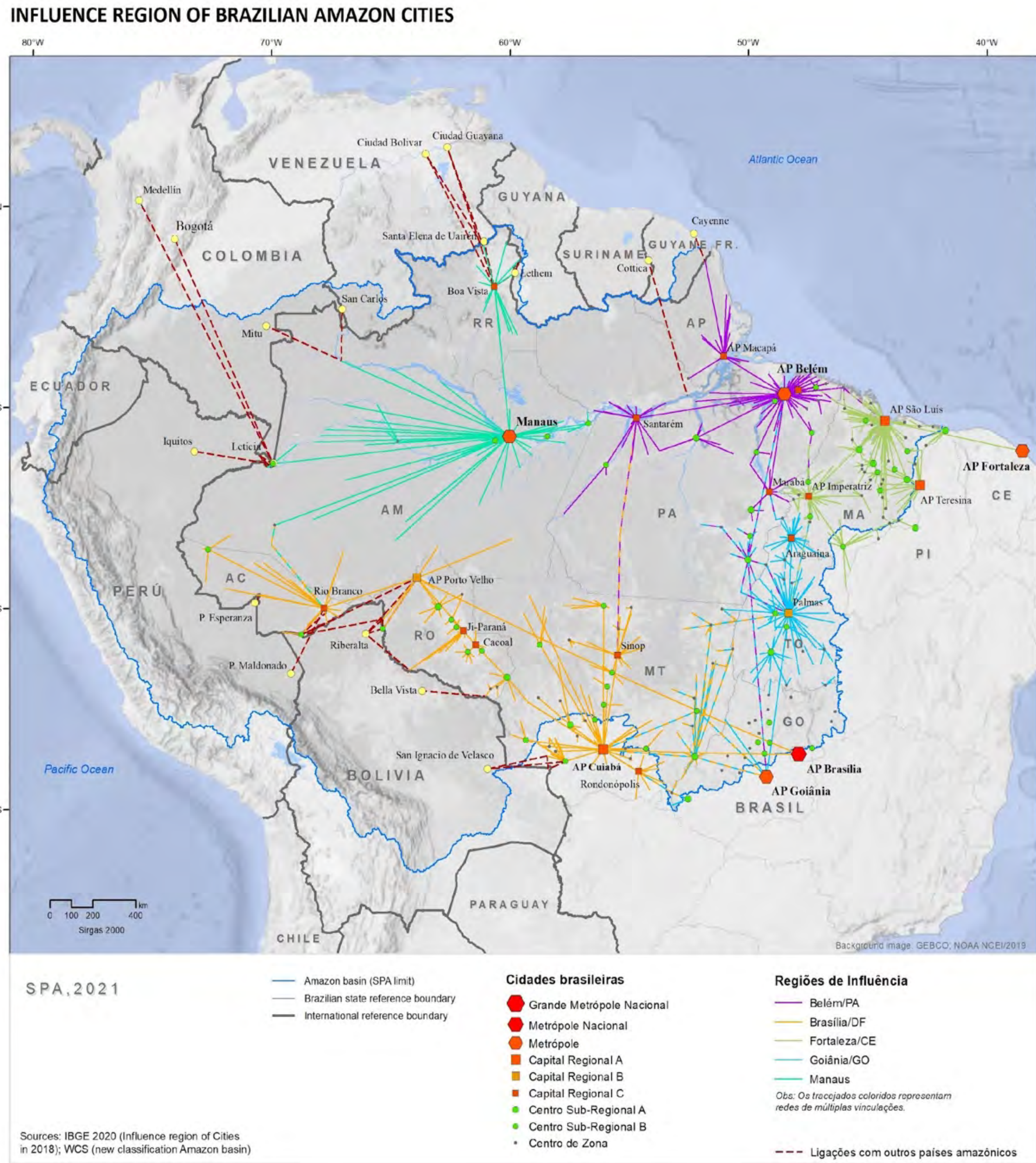


Figure 34.1 Spatial influence of large and medium-sized cities of the Brazilian Amazon. Note the huge area of influence of Manaus over a large fraction of the west Amazon, even towards foreign cities. Both the major urban population of the region and the dominant direction of social, cultural, economic, and political influence from the cities to the rural or forested areas have led to the coining of the term "urbanized forest" for the Amazon region.

By experiencing a world of intensification of flows and processes of artificialization, individuals become increasingly insensitive to situations, activities, and elements that are not linked to their direct daily experiences. The urban life, as the existential experience of the modern world, gives to the individuals exposed to the intense dynamics of a hyper-technology a kind of "desensitization" process (Simmel 2005; Sennett, 2005; Urry, 2008). Such a process causes urban-dwellers to not perceive the far-ranging—up to 1,000-km radius—impacts of urbanization on its surrounding forests and rivers. The tambaqui fish caught around Manaus, for instance, are half the size of those caught 1,000 km from the city, where the catch rate also doubles with increasing distance along the Manaus (Tregidgo et al. 2017). In that sense, both the content related to less evident environmental problems (such as the effects of climate and environmental changes) and the conditions for building an emotional bond with natural landscapes are seriously compromised. In the specific case of the Amazon and its most significant urban configurations, the presence of these three sets of values (the rural as a wild space, the inexhaustibility of wealth and the desensitization of the urban individual) decisively contributes to the development of the culture of disconnection. It is important to emphasize that this disconnection is stronger considering the relation metropolis and rural areas, or even medium-sized cities and rural areas. Solidarity networks exist and make a difference in the lives of residents of small towns in the Amazon. Those who live in the rural area of such municipalities send goods to urban families, such as açai fruit, fishing, or meat from hunting, to help with their maintenance. In contrast, residents of small towns do not send resources of any kind to these family members in the rural areas. However, their homes are used as a place to support these family members, for medical consultations, to receive government benefits, among other aspects (Costa and Montoia 2020).The perception of urban areas tends to be different for forest-dwellers and Indigenous people. "Urbanization" for Indigenous people is a multi-directional process often opportunistic and inspired by a range of drivers, the most common being labor opportunities, schooling, political work, and escaping village conflicts (Peluso and Alexiades 2005; Padoch *et al.* 2008; Alexiades and Peluso 2015, 2016; Peluso 2015). For them, movement back and forth tends to be flexible and reflects strong social, political, and economic relationships amidst the rural and the urban landscape (Andrello 2006; Alexiades 2009), but ultimately is a process that begins in people's minds long before they physically take place, and hence the idea that "urbanization begins at home" (Peluso, 2004).

34.1.2 The Urban Forest (Should Turn into Forest Cities?)

A major portion of the Brazilian Amazon Forest is urban, considering that >75% of its population is located in cities. However, the so-called "urbanized forest' term, coined by the Brazilian geographer Bertha Becker, is not restricted to demographical characteristics and express "*a tendency on the expansion and growth of cities in the region and, namely, of a lifestyle that is not restricted to the small towns and cities, but which defines social and economic reproduction in the region; process already named by Lefebvre (2003) as 'diffusion of the urban society'* " (Becker 2013; da Trindade 2013). As such, the concept of "urban forest" used for the Amazon region is key for understanding the dominant direction of social, cultural, economic, and political influences in the region: from the cities to the rural or forested landscapes (Fig. 1).

After the 1960s, as the region became a target of interest for expanding globalizing markets, policies were put in place to establish cities on the agricultural frontier, subject to regional policies (Becker 1991). In Brazil, this process was more intense and produced new cities such as agrovillages and company towns (e.g., Sinop), which grew from the influence of industrial production and agribusiness. Several other urban areas were influenced by the production and flow of goods: riverside cities, highway cities, industrial cities. Today such cities are a factor of change: migrants learn occupations and trades, whereas peasantry and its relation to labor is conserved and diluted (Bertha 1985).

Figure 34.2 Infrastructure deficit in the city of Afuá, Pará, Brazil (Source: Laboratório de Estudo das Cidades Collection/UNIVAP).

Figure 34.3. The metropolitan area of Manaus: an example of tensions between urban and rural contexts in the Amazon. Source: AmazonFACE/Nitro/J.M.Rosa

The region's historical migratory process from within and outside the region into cities has resulted in intense urban growth, which was not followed by investments in basic infrastructure. As a result, the Amazonian cities, which exert such an influence over the rural and forested areas, are generally devoid of proper access to Infrastructures such as sewage systems and water treatment, which, combined with adequate energy services and garbage collection, are essential public services to guarantee urban well-being (Brondizio 2016). Approximately 86% of Amazonian municipalities do not have an institutionalized sewage treatment service, and only 12% of the urban population is served with a sewage treatment system (Fig. 2) (ANA 2017). This situation becomes more complex when we consider that more than 80% of the Amazonian cities are small, with less than 20,000 inhabitants, a fragile economy, and an inability to improve investments in basic infrastructure.

Links (or lack of links) of people with these rural–urban exchanges in the Amazon region, there are intrinsic dependence relations, or "misrelations", regarding the trade of food and manufactured goods. Cities are now seen more as spaces for the flux of goods that inevitably connects to the region's trading hubs such as Manaus, Iquitos, or Belém and from there to global markets (Becker, 2013). Manaus is an example of an Amazonian metropolis where the tension between urban and rural areas is explicit (Fig 3). While focusing on the control of the territory and the flow of goods, there has been historically little concern regarding social justice, guaranteeing local food production and provision, health care, education, and other important elements in forest areas (Brondízio 2016). Inverting or equilibrating the weight of influence from the rural or forested regions to the cities could help improve well-being and other conditions for both forest- and city-dwellers in the region.

34.2 Addressing the (Dis)connections

The meaning, notion, or connotation placed on an object or event by a society, and adopted by its inhabitants, who influence the view or deal with the object or event, is the definition of the 'social construct' concept (Burr 2015). This concept is an important pact for the conservation and sustainable use of the Amazon and requires broad recognition of its importance by/for its urban population. This chapter presents a brief overview of this evaluative (dis)connection between cities and rural areas in the Amazon, pointing out the negative consequences for the sustainable development of the region, and providing some guidelines for building a culture of connection, affection, and ethics between urban and rural environments that can benefit forest conservation and the sustainable use of its natural resources. To that end, we present two major categories of relations: physical and cultural relations.

For physical relations (section 4), we briefly discuss the provision, use, and flow of material goods and services in the regions according to up-to-date scientific literature on the subject, also providing tentative but promising alternatives for improving the rural–urban connections from the perspective of such physical relations. In section 5, on the cultural (dis)connections between the rural or forested areas and cities in the region, we highlight a number of different culture-practitioners to provide, in their own view of their specific culture sector, how well- or badly established these cultural bonds are today, and how their strengthening is important to assure the long-term survival of the world's largest tropical forest. We conclude by summarizing a few recommendations about rural–urban relations in the Amazon, aiming at a long-term sustainable future for the region.

34.3 Physical Rural–Urban (Dis)connections in the Amazon

Approximately 80% of Amazonian cities have less than 50,000 inhabitants and are formally considered as small cities. Although they have a fragile economy, are strongly dependent on subsidies by the central governments, and have a low capacity to provide essential services and equipment such as education, health, and sanitation, small cities play an important role in the Amazon urban network (Costa and Brondizio, 2009). They represent opportunities to improve life for families by accessing urban services and employment opportunities that are deficient or even non-existent in rural areas. Conversely, large cities (>500.000 inhabitants) such as Manaus (Brazil), Iquitos (Peru), or Florencia (Colombia) function as regional hubs for the provision of services, commerce, health care, and other urban–rural relations. However, these physical interactions are far from ideal. In this section, we explore some caveats and opportunities for improving the connections between the forest and rural localities with cities in the Amazon from the point of view of "physical" relations, pertaining to the access, trade, and utilization of material goods, services (including ecosystem services), and information.

34.4 Formal and Informal Economy

The Amazon is known for its strong cattle and agricultural economies (including large-scale soya production), timber, forest products, gold, oil and gas, and the cocaine and drug trade, (Salisbury and Fagan 2013) all of which have strong informal tendencies and whose importance and differences vary across regions, e.g., soy-exportation in Itacoatiara or the oil-industry economy in Iquitos (Bunker 2003). The region's informal economic activity, based on subsistence, the extraction of raw materials and casual labor, is rife and linked to broader formal and international economies (Peluso 2020). As a result, the Amazon has intersecting informal and formal economic sectors, which exist in a symbiotic relationship (Peluso 2018).

A direct connection between today's Amazon with the global economy is promoted by the trade markets of such goods, which are unequal in many ways. For example, rich countries buy primary products with little added value (e.g., meat, soy, minerals) at low prices, and sell knowledge, technology, and products with aggregated value at high prices (unequal price exchange, *sensu* Prebisch 1962, Prebisch, 1950). To obtain more money for their exports, the Amazon countries are forced to extract increasingly more resources and sell them to developed countries (ecologically unequal exchange, Bunker, 1984, 1985; Martinez-Alier 2002, 2011). In addition, nutritionally adequate calories are exported at low prices (unequal calorie exchange, Falconí *et al.* 2017) and expensive calories with low nutritional content are imported. This has a double impact because the growing trade in primary products generates social and environmental damage in the places where they are produced or extracted—generally the rural areas.

Some cities have developed alternatives for escaping such globalization of local formal and informal economies, generating and diversifying income, and improving the relationship between cities and their surrounding rural areas. For example, cities on the island of Marajó (Pará/Brazil) have boosted the city's economy through ecological tourism (Soure), açaí production (Ponta de Pedras) (Fig. 3), and fishing (Afuá). These income-generating alternatives should be encouraged through state policies, promoting the valuation of the forest by this urban population. In that sense, a wider-developed bioeconomy—based on the respect of traditional way of production by local communities—would be one alternative for economic development for the Amazon as a whole (sensu SPA Chapter 30) if they are enacted sustainably without degrading the forest environments. No doubt that this incentive should be followed by an enforcement policy regarding the handling of some products such as acai itself. Although it has not yet been measured, it is known that the expansion of açai production has been followed by an expansion of the area occupied by palm trees, to the detriment of the diversification of forest species (Cunha and Fonseca Da Costa). Although the açaí economy is an excellent example of a bioeconomy, it can also lead to a loss of biodiversity.

34.5 Food Security

There is a substantial reduction in deforestation and increased family income when the following six points are considered: (1) safe land tenure, (2) appropriate technical assistance, (3) credit lines

Figure 34.4 Riverside community of Fortaleza located in the municipality of Ponta de Pedras, Pará, Brazil, which congregates producers of açaí fruit (Source: Laboratory of Estudo das Cidades collection/UNIVAP, 2019).

suitable for the smallholders, (4) minimum infrastructure for transporting yield products, (5) conditions to sell their products in cities —through institutional or open markets—provided by the local governments, (6) recognition and compensation for the ecosystem services provided by keeping forests standing (see also SPA Chapters 27–29) (Pinto *et al.* 2020; Souza and Alencar 2020).

It is remarkable that at least 4 of these points (2, 3, 4, and 5) depend on urban institutions or urban-to-rural infrastructure. Both the provision of appropriate technical assistance and appropriate credit lines for smallholders depend on institutions located in urban areas and a good deal of communication and presence of, for example, agricultural assistance and bank technicians with farmers and their land. Infrastructure for securing agricultural and forestry production flow to cities and establishing and maintaining the conditions to sell the yield products in cities depend on the level of connection of rural areas to cities and sociopolitical organization. Therefore, the physical proximity of food production units in rural areas to Amazonian cities seems to be key for improving or securing food in the region. In that sense, food production in "peri-urban" areas could be a way forward for effectively engaging urban dwellers in a forest culture and increasing producers' income, promoting forest conservation, and providing quality fresh food to urban populations in the Amazon. Indigenous and traditional communities should be actively favored for the establishment, expansion, or maintenance of such peri-urban food production belts around Amazonian cities, given their extensive expertise in staple agriculture in the region (Irazábal 2009; Schor *et al.* 2018). By promoting the valuation of local or regional food production in Amazon cities (instead of, for example, the nowadays common commercialization of protein (namely chicken) from outside the Amazon region (Schor *et al.* 2015)) these peri-urban food production belts could even foster changes of food consumption habits, (alternatives are presented in section 3; see also SPA Chapters 13 and 14).

34.6 Health Systems and Diseases

Rapid social changes tied to a globalized lifestyle have led to increased sedentarization, changes in diet and nutrition, which have led to increases in obesity, diabetes (Gracey and King 2009; Oliveira *et al.* 2011) and cardio-vascular problems (Liebert *et al.* 2013; de Souza Filho *et al.* 2018). Additionally, urbanization-driven soil and water contamination, as well as deforestation, have increased exposure to respiratory and contact infections, tuberculosis, and faeco-orally transmitted diseases (Kroeger 1983; Kroeger and Barbira-Freedman 1992). The incidence, immunity, and risk perception of a number of transmittable diseases such as malaria and tuberculosis are highly influenced by landscape characteristics, being amplified among more marginal groups within Amazonian cities and more controlled among traditional river-dwelling communities (Confalonieri 2005; de Castro *et al.*

2018). These lifestyle changes have also placed increasing pressure on local natural resources such as soils, wildlife, and timber, leading to feedbacks of environmental degradation and a concomitant impoverishment of health and nutrition conditions (Alexiades and Lacaze 1996; Piperata *et al.* 2011). For Indigenous peoples, health conceptually includes social, political, spiritual, and physical well-being, not only of the individual but of the community and the ecosystem (Alexiades 1999). Such positions mean that urban healthcare approaches are seen to ignore the underlying causes of illness in rural areas and are often only utilized by forest-dwellers as a last resort when health has already deteriorated.

The urban–rural framing typically depicts a scenario in which rural resources serve the needs of city folk, and these populations might often be seen to be in competition with each other (Brondízio *et al.* 2016). Indeed, healthcare professionals often view work in rural areas as a mere stepping stone to employment in cities, where hospitals and well-equipped clinics are located; therefore, they are often absent or disengaged in their temporary outpost medical care positions. This often leaves a void of western healthcare in rural areas and has spurred a series of initiatives on how to best serve these populations (Peluso 2021). In fact, the density of physicians in the interior of the Amazon (i.e., outside capitals) is amongst the lowest in entire Latin America, reaching values as low as 0.2 physicians per thousand inhabitants, whereas 4 is the minimum recommended by the World Health Organization (WHO) (Silveira and Pinheiro 2014). Apart from statewide vaccination campaigns, there have been a variety of approaches, such as that by the WHO in the 1970s to train local health care promoters through community-based approaches (Alexiades and Lacaze 1996), health care boats such as the Amazon Hope project, the Abaré hospital-boat in Pará, and the building of outposts in rural communities.

Nevertheless, the lack of health personnel and adequate infrastructures such as hospitals and first care centers are acute, and the advent of sudden large-scale emergencies such as COVID-19 further increases pressure on the region's deficient healthcare system. For example, widespread forest fires aggravate the health risks of COVID-19 through the augmented concentration of fine air particulates, which can worsen and increase the spread of respiratory (Alves 2020; Pinto *et al.* 2020; Oliveira *et al.* 2020) and COVID-19 infections.

Therefore, apart from the aforementioned itinerant healthcare initiatives and the potential strengthening of telemedicine, it is extremely important to have more subsidies and incentive programs for the long-term establishment of healthcare professionals in the region's small cities and rural settlements. This is tied to the improvement of other living and well-being conditions in these countryside places to make them, in addition to state incentives, more attractive to healthcare professionals. One of these conditions is, of course, the simple presence or improvement of infrastructure, including specialized equipment and installations to decentralize medical services from the major capitals to the countryside. Finally, a positive strategy for prioritizing healthcare in the Amazon is one that allows all local populations—whether rural or urban—to nurture, maintain, and rely on resources that are readily accessible to them. An example of that is the SachaWarmi (https://www.sachawarmi.org/) in Ecuador, who facilitated videos that explain medicinal plant use in practical terms.

34.7 Knowledge Infrastructure and Human Capital

When dealing with Education in the Amazon, a deep approach is needed in which public policies still need to evolve; where formal basic education (kindergarten, elementary and high school) has a very limited form and serious problems that include scarcity and precariousness of physical spaces. In addition, vocational courses and higher education are lower levels compared to the rest of the country. In the State of Amazonas, Brazil, a solution found by the Secretary of State for Education and Sport (SEDUC acronym in Portuguese) to expand the provision of education in elementary school is face-to-face teaching mediated by technology.

Implemented in 2007, the Amazonas Education Media Center (CEMEAM) is a pioneering state policy in the country. Unlike distance education, this has the presence of students in classes, real-time interactivity resources, and strategically planned media for the development of synchronous and asynchronous classes, making use of a videoconference satellite system with audio and video interaction. Classes are produced by expert teachers and turned into television pieces in an educational production center for TV, using various media resources and communication tools and broadcast live, daily, to all classrooms simultaneously, at regular time. Each classroom has a technological kit and a face-to-face teacher to mediate the learning process. It is present in all 62 municipalities in the state (www.centrodemidias.am.gov.br).

In 2010, the Sustainable Amazon Foundation (FAS) started the construction of nine Conservation and Sustainability Centers (NCS) located in the Conservation Units where the institution operates. Aiming to offer education to remote areas, in addition to supporting the government and providing education and health solutions adapted to local realities, the NCS include classrooms, cafeteria, kitchen, library, accommodation for students and teachers, operational base, and computer labs. The centers also offer formal education within the modalities of elementary, secondary, youth, and adult education (EJA), higher education, post-secondary technical, and free professional courses. It is in these centers, through partnerships, that complementary projects are developed that encourage young people to build life plans, training, and practical experiences.

This structure enables experiences such as the “Repórteres da Floresta” (Forest Reporters) initiative, which works to form a sensitive and sincere look at the local reality through "educommunication" workshops and the creation of communication products. Students also develop innovative solutions for income generation and entrepreneurship, learn leadership techniques to assume important roles within the community, experience reading in its multiple possibilities, tell and retell stories and explore the field of performing arts through the production of theatrical shows. FAS also has a look directed to the appreciation of teachers, investing in training through the development of materials and methodologies with contextual themes and focus on sustainability and the environment for those who work with multigrade classrooms, a reality of communities.

Thus, two recommendations are proposed in relation to forest-city interaction in relation to education in the Amazon: (1) establishment of physical hubs for on-site education in remote locations, aided by remote teaching technologies, and (2) training and stimulus programs for the establishment of teachers, preferably coming from the interior communities themselves, since they already know the realities experienced by these populations outside the large urban centers in the region.

34.8 Green Infrastructure as Nature-Based Solutions

Green infrastructure is an increasingly employed concept for the planning of urban and rural landscapes and can be understood as “the connected network of multifunctional, predominantly unbuilt, spaces that support both ecological and social activities and processes” (Kambites and Owen 2006). Although green infrastructure is sometimes treated as a planning issue (Pauleit *et al.* 2011), in practical terms, it can be seen as the physical green spaces, planted trees, and the corridors connecting them that provide multiple ecosystem goods and services (Tzoulas *et al.* 2007). Green infrastructure has proven to be a useful mechanism to support cities in solving common urban problems, such as urban heat islands.

Apart from a few isolated cases, such as the Acariquara neighborhood in Manaus (Fig. 4), the forest does not permeate urban spaces in Amazonian cities. In fact, Brazilian Amazon capitals such as

Figure 34.5 Contrasting presence of green infrastructure in neighboring locations in the city of Manaus. (a) High permeability of green areas and residential buildings in the Acariquara neighborhood; (b) urbanization with very low presence of streets in the Ouro Verde neighborhood.

Manaus and Belém are amongst Brazil's cities with the smallest green coverage (IBGE 2012). There is extensive evidence on the benefits of greening urban spaces, including contributions to the physical and mental health and well-being of urban-dwellers and lowering of air and surface temperature maxima and variation (Fig. 5) (Norton *et al.* 2015; Amato-Lourenço *et al.* 2016). It is estimated that a 10% increase in tree cover may result in a 3°C decrease in local temperature (Elmqvist *et al.* 2013; de Bello *et al.* 2017).

Several other urban issues could be mitigated by establishing such nature-based solutions into city landscapes. Among the examples are flash floods, landslides, water security, air pollution (especially of particulate material), noise pollution, usage of indoor air conditioning, greenhouse gas emission balance, and even the generation of “green” job posts (Chapters 27–30) (Raymond *et al.* 2017; Nagabhatla *et al.* 2018), as demonstrated for the peri-urban areas of the Amazonian city of Puyo in Ecuador (Huera-Lucero *et al.* 2020).

An increased occurrence of green infrastructure in three large Amazonian capitals (Manaus, Belém, and Porto Velho) has been preliminarily estimated as costing USD 70 million per year, or USD 15.00 per inhabitant per year (Lapola *et al.* 2018), a feasible cost, especially if one considers the incurred monetary benefits such as the consequent energy-savings related to air conditioning. In small and medium-sized Brazilian Amazon cities, the cost would be even lower (USD 7.00 per inhabitant per year, Vieira and Panagopoulos 2020). Nevertheless, despite the hyperdiversity of approximately 15,000 trees species of the Amazon ecoregion (ter Steege *et al.* 2020), more than 40% of the trees in urban areas of the Brazilian Amazon cities are exotic, such as *Ficus benjamina* native to Malaysia (Vieira and Panagopoulos 2020).

There are practical barriers to the greening of Amazonian cities to the level at which these benefits are perceptible. The first is the lack of tax incentives for properties with trees and adaptation of city-level services to cope with such a high tree coverage (e.g., pruning)— again, a cost that is probably smaller than the energy spent on cooling interiors or dealing with health impacts of extremely high temperatures. A substantial greening in these cities (as the example given in Fig. 4) would also demand moving underground a large fraction of the urban electric wire network. But most of all, there is a cultural barrier to be surpassed when it comes to keeping street trees and green spaces in Amazonian cities (see boxes 7.1, 7.3, 7.8, and 7.9 for examples). Many inhabitants of Manaus, for example, do not want trees on their streets or backyards because they associate the presence of trees with dirt, forest people and, therefore, poor development (Lapola *et al.* 2019). Moreover, the permanently constrained budgets of city governments force them to abide by continuous gentrification and allotment of urban spaces that, if better planned, could have a well-equilibrated presence of green infrastructure. Although it is reasonable to assume the small and medium-sized Amazonian cities have the same demands as large cities in terms of the presence of green infrastructure, these small and medium-sized cities generally operate on a lower revenue and skill basis (Pickett *et al.* 2013). In that sense, state- or federal-level coordination for

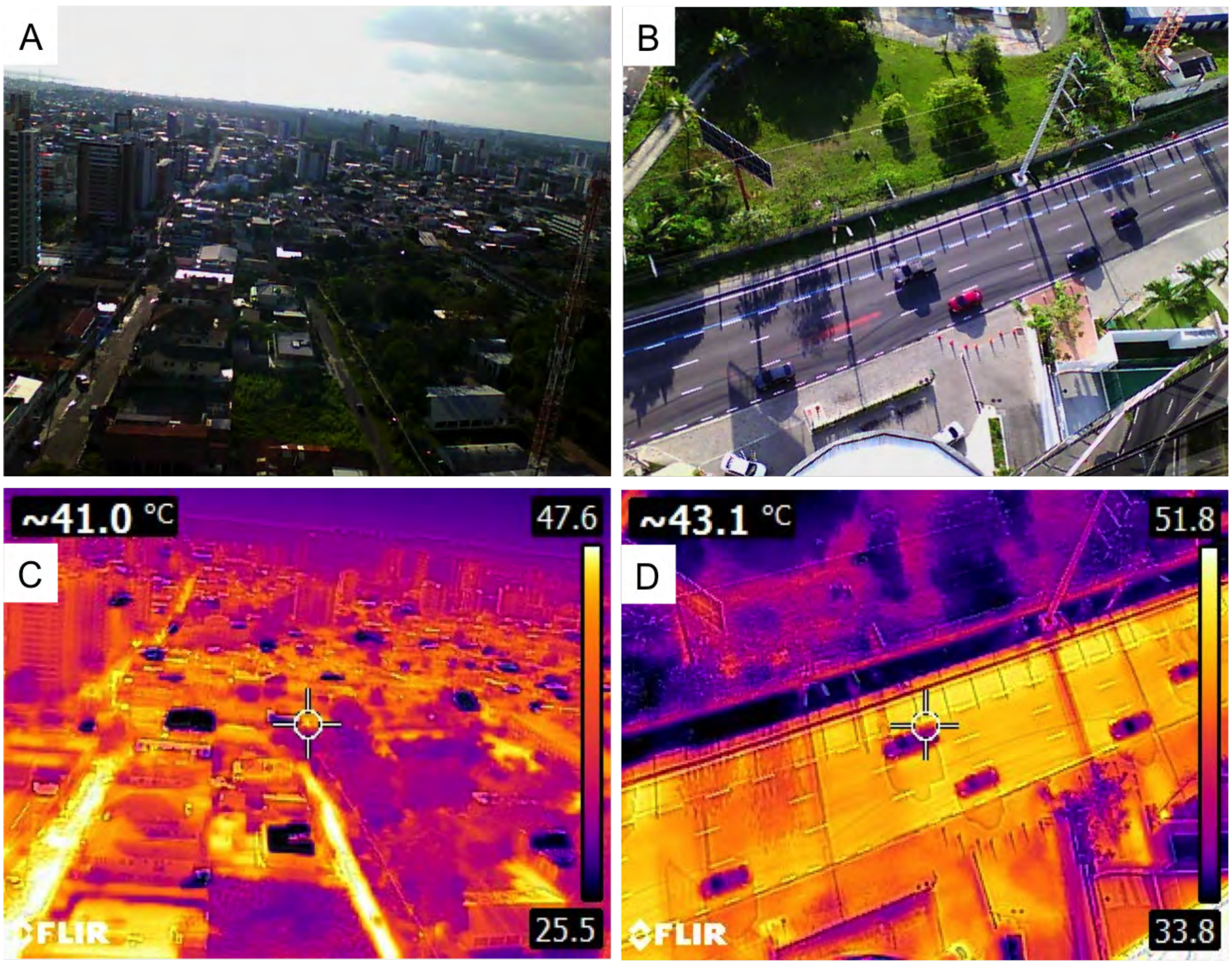


Figure 34.6 Visible (A,B) and thermal infrared (C, D) pictures taken from locations in Manaus city in October 2016 as examples of poor insulation and poor energy conservation in buildings due to air-conditioning (A, C) and cars (B, D) and the importance of vegetation to ameliorate urban temperatures. The top left number denotes the temperature at the target in the center of the image. Source: Lapola *et al.* (2018).

the provision of financial and technical conditions for increasing such infrastructure in small and medium cities is key. We also suggest that clearly demonstrating the financial and well-being net benefits of urban green infrastructure, in a participatory way, might be another way to increase the presence of green infrastructure and green spaces in Amazonian cities, which could ultimately turn more fluid the transition between urban and rural areas in the region.

34.9 Information (Smart Cities, Smart Forests)

The popularization of the internet has undeniably improved communication between small settlements and large urban centers in the Amazon, from entertainment purposes (Colferai 2013) to optimization of agricultural yields (Furtado *et al.* 2020) and even telemedicine (Machado *et al.* 2010). However, the Amazon is one of the regions in Latin America where the digital divide is the strongest, especially considering the differences between urban and rural areas. 72% of households in the Brazilian Amazon make use of the internet, but this percentage is higher in urban areas (83%) compared with the rural households that access the internet (33%), representing the highest urban-to-rural difference regarding the use of internet in Brazil (IBGE 2020). The main reason is the lack of internet services in the region. Communication via internet with rural or forested areas is highly dependent on wireless networks, namely, via radio networks. What happens in the forest/rural areas also affects cities: for example, forest fires in rural areas seem to affect the internet signal in large cities such as Manaus (Medeiros 2020).

Using the concept of "smart cities" (highly participative exchange of information through sensors and devices for better management of resources and services (Cunha *et al.* 2016)) for boosting rural-urban relations could bring about benefits much beyond the improvement of communication in the Amazon and elsewhere. In that sense, the concept of "smart forests" (or "internet of trees") should be popularized in the region: highly technologized forest sites for data collection, processing, and analysis, not only for anticipating fires but also for managing other environmental changes, the sustainable use of forest resources, and the understanding and involvement of urban people with the forest (Gabrys 2020).

One clear example is the use of smart forest technology by the Rainforest Connection initiative (https://www.rfcx.org/) to alert authorities about deforestation, logging, poaching, and smuggling activities. This initiative uses second-hand cellphones to monitor the sounds in remote rainforest locations and generate alerts when the sounds of chainsaws, motorcycles, or trucks are captured. The system is currently employed experimentally in the Tembé Indigenous Reserve in central Pará, Brazil. Other examples include the remote sensing, with cameras, of the production of forest fruits, the *ex-situ* monitoring of forest flammability, industrial-scale tree planting for reforestation or creation of green infrastructure in cities, and the building of cultural connections by sharing touristic information with the urban population, such as the reproduction season of river turtles. The area is still wide open for innovation, and many other examples of such relationships between urban and rural areas in the Amazon regarding the exchange of information and the role of social media are expected in the next years or decades.

34.10 Connecting Culturally with the Forest

Obviously, the forest culture does not go unnoticed in the Amazon metropolis and many other cities of the region, for example, through food consumption habits (consumption of local forest fruits and native fish), traditional festivities (e.g., the Parintins "Boi" Festival) and even through the use of plants with psychoactive compounds for religious purposes in the urban context (e.g., the ayahuasca brew). These unique Amazonian cultural assets are indeed part of everyday life in the region's cities and already represent good connections between the urban and the rural forested Amazon. Although these examples of good connections can be important instruments to help in rural–urban (re)connection, they are not sufficient to secure deep relations between the local urbanized society with the forest to benefit its long-term existence.

In Manaus, which has approximately 2 million inhabitants, only a minor fraction of people see the surrounding forest as part of their living and cultural space (Higuchi and Silva 2013). In small cities (i.e., <50,000 inhabitants), the relation between nature and urban citizens is more intimate and more solidly established, but not always in a synergistic way. The Brazil nut (*castanha* or *castaña*) harvest intimately drives seasonal socio-cultural cycles in small towns of Bolivia's Pando department (Cronkleton *et al.* 2010). On the other hand, many small cities in the Amazon are responsible for the highest deforestation rates; for example, Lábrea (Brazil) has only approximately 38,000 inhabitants but is among the top-ten deforestation municipalities in the country, with a deforestation of 390 km^2 in 2019 (PRODES, 2020). The improvement of this connection between urban-dwellers and a culture of and for the forest should be accomplished by (re-)touching/instilling people's innermost values, feelings, and beliefs with a forest-based culture.

34.10.1 Are Amazonian Cities Culturally (Dis)connected from the Surrounding Forest?

One of the major challenges humanity faces today is that many of us have lost the vital connection with the living world that sustains life (Beck, 1998). This is as true in the Amazon—whose human population is increasingly urban and subject to a globalized, flattened culture— as in the rest of the world. It is of paramount importance that we stop the relentless destruction of the planet for the well-being of the planet itself and for the survival of humanity as we know it. Preserving the forest is not only central to maintaining biological and carbon assets but also from a cultural point of view.

Biological and cultural diversities are interrelated and mutually supportive (Maffi 2010). Many traditional practices are tied to ecosystem health and resilience and should be considered as the pillars of biodiversity conservation (Porter-Bolland *et al.* 2012; Frainer *et al.* 2020). The current hyperdominance of domesticated native trees in the Amazon is frequently associated with pre-Columbian Indigenous peoples (Levis *et al.* 2017). The so-called biocultural diversity (Maffi 2010) is also evidenced by the linguistic diversity (70% of all the languages on Earth) associated with the biodiversity hotspots (Gorenflo *et al.* 2012). A central tenet of this vision, shared by virtually all Amazonian peoples (e.g., the Sarayaku Indigenous people in Ecuador) is that the world of the forest, the world that is often referred to as nature, is in fact populated by a diversity of selves—persons, or spirits— who live in constant communication with each other and also with us, if we could only hear them (see boxes 7.4, 7.5, 7.7, and 7.10 for empirical examples).

The Sapara Nation in Ecuador/Peru (www.naku.com.ec/declaration) developed a unique communal initiative to take people to the forest and allow them to experience, first-hand, what it means for each one of us to live with a living forest. Heeding the Saparas, we realize the way in which we listen to the forest can be a profound spiritual and ethical practice that can remake our lives and the ways we view and treat nature. Forest dwellers do not recognize a sharp division between human culture and nonhuman nature. Nor do they think of nature as an inanimate resource that can simply be exploited for human benefit. Rather, we all form part of a vast "ecology of selves." What we share with these other selves is a fundamental interiority, a selfhood, a spirit, a soul. This understanding has been well-documented in the ethnographic/ethnoscience literature (Maffi and Woodley 2012; Descola 2013). However, only recently has this been accepted as possibly true by biological scientists (Kohn, 2013).

Religion is also paying attention to the pivotal role of the Amazon: once a religion bent on extricating idolatry and converting natives, the Catholic church today, under the guidance of Pope Francis, is heeding Amazonians and beginning to see the forest as a source of spiritual guidance (Pope 2020). In the same direction, the rights of Indigenous peoples are both nationally and internationally (by United Nations and the Inter-American Commission on Human Rights) recognized and three Amazonian countries have constitutionally or legally recognized the rights of nature: Ecuador, Bolivia, and Colombia.

Notwithstanding, there is no straightforward and simple recipe to make the non-forest people, the urban dwellers, genuinely feel and recognize themselves as being culturally, spiritually, and affectionately closer to the world's largest tropical forest. Although practicing a more rational economic use of the forest—for example, through a standing-forest based bioeconomy—is certainly a way worth pursuing for the future of the Amazon (see SPA Chapter 30), the long-term existence of the forest will be better secured by winning the hearts and minds of urban-dwellers about the importance of the forest and its role in their daily lives (examples on how to fill this gap are given in the cultural practitioners' testimonials below). Therefore, peoples who live intimately with the forest have a vision of a good life or *buen vivir* (widely understood as *18umac kawsay* and other terms in Indigenous languages), that, if heeded, can help put a brake on the modern idea that the forest is an inanimate resource to be exploited for the sole benefit of humans.

34.11 Practitioner Reflections on Reconnections

Amazonians who live with the forest understand the world "like a forest" and are mobilizing politically and through media to show us how they think with and like a forest (e.g., Kopenawa and Albert 2013). Compared with forest-dwellers and traditional population, Amazonians who live in cities, especially in medium and large urban centers, have a distinct mindset of values and inherited culture, and, as such, one should not simply foster their appropriation of Indigenous and traditional people culture, but rather resignification or refoundation of the cultural bonds of urban inhabitants with the forest, supported by the forest people and their ways. "In the end, we will conserve only what we love; we will love only what we understand and we will understand only what we are taught." (Dioum 1968). And this is not an endeavor for scientists alone or forest people themselves but for people from both the forest and city cultures to suggest how this transformation could be carried out.

Therefore, we present a set of testimonials from cultural practitioners from ten different sectors: architecture and urbanism, cinema, education, health and healing, music, press and communication, spirituality, sports, tourism, and visual arts. Preference was given to non-academic distinguished cultural practitioners based in the Amazon region, attempting to secure a reasonable gender and geographic balance. The selected cultural practitioners were asked to record a five-minute video to provide their testimonial; the contents of those videos are transcribed in the boxes below. They used their expertise in the specific cultural sector to let the world know how their practice field can help build this new cultural, spiritual, and affective vision of the Amazon forest. At first glance, these testimonials are as diverse as can be, not only in terms of the sectors—from urbanism to spirituality—but also in terms of the personal background of the cultural practitioner. They all encourage the establishment of a culture of (re)connection of people with the forest through different but interconnected ways.

Laurent Troost talks about an "encounter of people with nature inside" through better urban planning, whereas Zienhe Castro uses the terms "connections" and "exchange" that cinema can promote. Markus Zangas talks about providing "opportunities to be in nature" for our children, and the great *pajé* Mapulu Kamayurá an invitation that "you come to the forest to help" secure the existence of what she sees as the "pharmacy of the world" for the current and next generations. Nadino Calapucha, talks about a "walk in unison" through the power that music has for establishing or strengthening our relationship with the forest, and Sônia Bridi suggests that showing the "infinite beauty of our planet" on television, the Amazon included, is key for re-establishing what she calls "the lost connection" with the forest. Manari Unishigua, the akameno (authority) of his nationality,

BOX 34.1 Architecture and Urbanism
Laurent Troost

Hi, my name is Laurent Troost. I am an architect, Belgian, living in Manaus since 2008. I have worked as director of urban planning in the city of Manaus for the last eight years.

I would like to make a few points for this very important project, in two chapters: the first is related to the architecture and professional practice of my colleagues, and the second to urban planning and urban strategies to improve the cities in which we live in the Amazon.

Regarding architecture, I would like to say that it seems to me that the most important thing—and this is also what I practice in my day to day—is to work with nature, with this idea of integration, but more than that, it is about preservation and confrontation with nature. Why do I say confrontation? Because today, there is a cultural prejudice that perceives vegetation in a negative way in Amazonian cities. So, today we must confront, provoke the encounter of nature with the users of this city, so that little by little they realize the benefits that it can bring to them.

[In regard to] The matter of preservation, obviously, nature can be treated as the replanting in the city and is often done this way, but more than that, it seems important to preserve any type of biotope or biological system, even if they are a lake, water, what may seem like a poor quality vegetation in the eyes of the first passerby, but sometimes it has much more value than that. (...)

What would be the purpose of this? It seems to me that it is important to reverse the commercial logic of many Amazonian cities' master plans, that, as in the case of Manaus, for example, [which] has reversed, has abolished, the question of the mandatory permeability share of land [tracts], something that seems absurd to me, but there are forces that fight for this, in order to allow a wider occupation of the land. It may seem like a small detail, but which totally transforms the urban landscape.

urges for a look at the forest from the "spiritual world" perspective, where life is suitable, with no diseases, doubts, or complications. Complementary to that spiritual vision, James Junior and Pedro Nassar, advocate that felling, working out, and placing our physical body inside the forest, either for sports or tourism, boosts this "affectional bond" with the forest and its people. Denilson Baniwa brilliantly concludes the argument by saying that in fact "everything is people" in the forest, which takes us to the conclusion that we are in fact the forest.

Rather than being an authoritative statement on how the bonds between urban populations and the Amazon Forest can be better fostered, it provides a broad first-order initiation of this relevant discussion (considering that many other cultural sectors, such as food habits, fashion, literature, photography, and social movements are not covered here). We understand this exercise as key for the transference of the scientific messages of this report to non-academic societal spheres.

34.12 Recommendations: Paving the Way for Transformation

In this chapter, we attempted to systematize the underlying causes of the rural–urban relations in the Amazon region, their current status and possibilities for improvements, both from the physical and cultural perspectives. Although different sectors of such physical and cultural connections were analyzed separately, it is reasonable and desirable that the alternatives for boosting these relations in each sector are done in conjunction with each other. For example, there cannot be a stronger link between rural and urbanized areas regarding food

BOX 34.1 *cont.*

Another front line (...) is to fight against the spread and in favor of the densification of cities. This may seem controversial to the preservation within the city, to densify more, to build more, but in fact this will be much better for the forest (...) or for some spaces within the city because they will have a higher value (...).

Regarding density, the city itself is denser, right, it's not because the small one cannot incorporate vegetation and preserve biological systems. So we have to, from this perspective, look very carefully at neighborhoods like here in Manaus, I would say the INPA [Brazil's National Institute for Amazon Research], UFAM [Federal University of Amazonas], and Acariquara, which are neighborhoods where the vegetation is extremely well integrated. However, if the whole city were like that, the city could be extremely widespread (...). So we have to think about a model that is more efficient than those that I just mentioned.

Another point that political action could guarantee is the mandatory preservation of tree species. There are a number of cases of upper class gated communities, large size enterprises, in which it would be much more interesting if a mandatory tax existed about the preservation of native vegetation instead of the land occupancy tax that does not guarantee anything. (...)

Another [point] is to work politically, legally, to compel cities to recover environmentally, [and integrate] urbanistically, the countless watercourses that are either invaded or degraded. Today smart cities make use of mapping tool [for such water courses and invasions that took place after the Forest Code law]. Thus, there is a legal jurisprudence, which would allow to remove the people who invaded. Of course, it is not done simply like that, one has to go discuss it with the invaders, but without the determination of justice, the city halls never see this as a priority, because, first, there is a lack of money [at the municipality budget] and, second, there are [always] other more important priorities. The needs are great in Amazonas.

To finalize this contribution, I would like to put a dream, the ideal that, just as in recent years literature and urban practices are highlighting the Transit-Oriented Development (TOD) as a way of restructuring the city, from a mobility perspective, it doesn't see mobility just as a component, [but] it can be a component that adds quality and requalifies [city] streets. (...) we could imagine, a dream would be a society that restructures its cities, using E-TOD: the Environment and transit-oriented development; to use the transformations, like the one I just mentioned of a watercourse recovery, to not only solve an environmental problem, but to restructure the city [turning it] more equitable, sustainable and [providing a] better quality [of life].

BOX 34.2 Cinema

Zienhe Castro [originally in Portuguese, translated to English by Nathália Nascimento]

[Zienhe Castro, from Pará, is a filmmaker, producer and screenwriter at ZFilmes. She has been working as a cultural producer for 30 years. Since 2009, she has been responsible for the foundation, general direction, and curatorship of the Amazon Doc Film Festival, a Pan-Amazonian Film Festival which involves the nine Amazonian countries.]

I believe in art with a transforming power, with this power of impact on all of us and I think that cinema is an immensely powerful tool in this aspect, which produces a reflection that disturbs, that provokes,

Box 34.2 *cont.*

and that instigates discussions and debate of different themes. Both fictional and documentary cinema have this important role, not only to entertain but to provoke society to reflect.

In 2009, we founded a group that I coordinate, which organized and continues to produce a film festival to create bridges and build dialogue between the different Amazons, which is Amazônia-Doc, the Pan-Amazonian Film Festival. I think that one of the most important things we achieved was to establish a dialogue between the different Amazons, Amazons that have both commonalities and differences, but that add up and can be enriched. I believe that we Amazonians, through cinema, in the last ten years, managed to connect because of cinematographic works, of a cinematography that was found in these rivers, in these waters, in this forest, which I usually call "The forest of cinema and the cinema of the forest" to talk about the Amazon. And I think this contributes effectively to finding solutions for the forest, to finding this reconnection with the forest. And I believe that cinema, it really contributes in a very powerful way to these encounters.

It is vital to promote and democratize access to these films, to inspire new filmmakers and reach new audiences. We must promote debate and bring people together around the issues and themes raised by cinematographic works. After more than a decade as a director and curator of films in the Amazon, I believe in the enormous contribution of cinema as a vector of connection, encounter, exchange, awareness, and understanding of the peoples who inhabit the macro-region that extends its forest across the nine countries that make up the Amazon territory.

BOX 34.3 Education

Markos Zangas

Hello, my name is Markos Zangas. I have been working with children and nature for the last twenty years in two capacities: one capacity is of taking children on outdoor adventures, so rafting and kayaking, cycling, hiking, camping—outdoors—and the other one is providing environmental education programs in nature for schools and students. I have also been working for the last 5 years with a Danish organization (Inside-Out Nature organization), training teachers around the world on how they can incorporate nature and forests in the pedagogy, how they can use nature and forests as grounds for a holistic development of children.

I have seen this as a very important thing to offer children these opportunities because the global tendency is that children are gradually disconnecting from nature. And that is seen in small villages, it's seen in big cities, even in big cities like Manaus that are next to the forest. There is this disconnection and it is even more so as the years pass, when a young parent has not had that opportunity as a child to be in nature, and doesn't have that connection, they can't see the value, they don't have those memories to try and offer their own children the chance to be in nature and spend time there. So, this disconnection is becoming much more apparent in the last few decades and there have been studies demonstrating how this has detrimental effects on children, [and that] the fact that our culture no longer incorporates being in nature, how it has affected children's mental health. This could be higher stress levels, it could be early signs of depression, but can also be their physical health – child obesity and poor motor skills.

Box 34.3 *cont.*

Around the world, there has been a tendency of including and creating a new culture of using nature not only as something that we have to protect but something that has to be a part of us and a part of education—whether it is the education schools provide or the education that parents provide. When children have these opportunities to be in nature, they have so many benefits and again there have been studies that demonstrate how they benefit children through outdoor play—whether it's their mental health that we mentioned, or their physical health, they exercise more, they run more, they develop more strength, they develop better immune systems. (...) When you are in an environment that is very hospitable such as a jungle or forest, where you have to adapt to the weather conditions or you have to test yourself on hiking or trying to climb a tree—all these problem-solving skills—you learn more about yourself and become more confident. You learn how to take small risks—so these are all really important skills for children to develop when they are in nature.

It is not hard to reverse this tendency, this disconnection—to offer more opportunities to children is not really something new, it's not some new pedagogy in forest and nature school, it's not new, it's not expensive, it's really returning to the basic roots, this is nature, this is forest, where we have developed as a species. It is really our natural surroundings, our natural biotope. It's not something primitive, it is an essential part of who we are. We need to have these opportunities to be in nature, even if it's once a week or on the weekend. It's quite easy to offer—parents go into parks, head into the forest for the weekend, have camping trips, or maybe through schools that offer it as a weekly or a monthly excursion, heading into the forest and having that opportunity to reconnect and appreciate nature. If we start looking at the forest surrounding our cities like Manaus, Iquitos, Belem, the vision and the culture changes of how we envision forests for our children and we start looking at it as a free theme park, or a school where children can learn about nature and themselves, or as a gym where they can work out. It's all of these things at the same time. (...) I know many parents might fear, might think about the risks of playing outdoors. But really, it's not much riskier than riding a bike in the city or climbing a metal play structure. (...)

There is also another positive outcome from children being outdoors – when children have these experiences in nature, they develop an appreciation for the environment and as they grow up it's much more likely that they develop environmentally-friendly attitudes and habits. (...) So, if we are to create a new culture and a new vision of how we perceive [and interact with] the forest, I think it should definitely also have the perspective of children.

And children, families and schools should look at the forest and the Amazon as a play escape, as a place for education and development of the children because it will benefit the children but will also benefit the forest.

BOX 34.4. Health and Healing

Mapulu Kamayurá

Good morning, everyone. My name is Mapulu Pajé Kamayurá [shaman and women leader at south Xingu Indigenous land]. Look, I am transmitting my concern to you. I am really worried, because as a shaman, I evaluate the forest looking at spiritual animals, that are bleeding a lot. For us the forest is important, for us it is very important. Why am I saying this? The forest is important to us because it is

Box 34.4 *cont.*

there that we look for medicine, roots... For us the forest is a kind of pharmacy. It is there that we look for medicine, and when you are in pain, you go to the pharmacy. It is the same thing. We keep this forest to store medicine. (...) That is why we protect the forest.

When people get the snake bite, we look in the forest, we look for medicine there. When they get pneumonia, cancer, high blood pressure, we look for medicine in the forest. Pharmacy that we call it; I call it pharmacy. That is why we don't want to lose it, we... we don't want to lose the most important medicine for us. Folks, forests... we search for medicine there, when the child has pneumonia, diarrhea, we go there to take the medicine, then we say to the "raizeiro" [knowledgeable person on the identification, harvesting and medicinal use of forest plants]: "he will get medicine from there, to give to the patient", that's it, the raizeiro deals more with roots.

When a patient comes to me, first I evaluate what he/she has, I heal, I show to the family, I tell them what he/she has, I pass it to the raizeiro and he takes it out [from the patient]. I do not heal pneumonia, high blood pressure, diabetes, these three I do not heal, just the raizeiro. That is why I have a lot of pity about the forest, this is a pharmacy to me.

When "spiritual" attacks a person, then yes, then this is with me, I heal. When he/she has a headache, I heal, the column, this is with me. I heal all of this, when spiritual attacks people. Now, the raizeiro deals with roots. My husband is a great raizeiro, he knows how to handle it, he has treated many people coming from the city. I see here at the Xingu who has diabetes, high blood pressure, that comes to treat it here in the Xingu. Cancer is treated here... When you need to get treatment, come here to get treated. There is more medicine here as well. People say that there isn't... there was a person who said there was no way to treat it, so he came here, we treated him, my husband healed him. He went back to the city, to São Paulo, we treated him here, I was accompanying him a lot as well.

For us shamans, health... I am a people healer. The life, I heal people. I have treated in the city, Brasília, a boy who was... he was in the ICU for three months, I took the boy, right, he went to... He went out, and they told him that serious illness was incurable. I asked to... His mom asked me to heal him, took him off the hospital, from the ICU, and I treated him. Today the boy is going back to study.

That is why we need support, who want to participate can participate here. (...) When the spiritual does bad things to someone, why is he doing a bad thing to someone? Well, there is no more home, no more home... people here are killing a lot of wood, then that is why I am telling you. I am asking you a favor, that you come here to help me, is that possible? Let's make a kind of a project, let's create a project to raise this forest, right, we do the farming and we don't put down a lot, we put down a little, we hold.

People are sick about wood. Why do we get sick of wood? Because it is it what is taking our health, this wood that is taking our health, if we end with the wood, forest, we will be, we will feel weak, we will be... will be... we will not be happy, because we have already killed all of the wood, that is why us, that is why I protect more, right, folks? That is how I pass this to you, I am a shaman, right, and that is why I am telling you this, so you can support me, me, who heals. (...)

Bye, folks. Anything, any questions, you can tell me. (...) Bye to you, take care, let's go, let's fight. I am fighting for my people here, so this disease does not arrive really strong here at the Xingu.

BOX 34.5 Music

Nadino Calapucha

I am Nadino Calapucha of Kichwa nationality of the Ecuadorian Amazon, and I am one of the members and founders of the Kambak group. The group, which emerged in 2013, is aimed at inviting children and youth, through music, to fall in love with, become fond of, and empower themselves with their language, their culture, their history, and, above all, to join the struggle and protection of our shared Amazon.

In recent years, we have made great strides and had great achievements. It has been incredible to see the children singing in the Kichwa language; in many of our concerts, having many experiences that the communities identify with this music has been wonderful! In contrast with this society that has been dominated by western music and western culture, we have been moving away from our principles but Kambak's proposal is not that they will only fall in love with our culture, the important thing about this project is that we are inviting them to walk in unison, on the one hand with the knowledge and insights of our peoples and on the other, with the knowledge and knowledge of the western world. Within the framework of interculturality, in fact, we have mestizo members in our group who have joined this initiative from the urban areas, so it also has an intercultural aspect. We want to invite the world to build this potential society within the framework of respect. We have also had an international achievement, by being recognized by the Fund for the Development of Indigenous Peoples of Latin America and the Caribbean (FILAC) in 2019, as one of the innovative youth projects. That was incredible and it has motivated us to keep working diligently. Going forward, we want to continue this, working with children and young people because we consider that it is important to listen to their voices, although it is true that the Amazon and its peoples have until now been considered a myth. Us, Indigenous peoples after 528 years of resistance, are still here demanding the fulfillment of our rights, defending our territories and we want to tell the world that we are still here. The Amazon region significantly contributes to the gross domestic product of the countries of the Amazon basin. However, we have been the most excluded, the most forgotten, and much of the time considered a myth in many of the countries. Together with the western world, we want to build what's possible in society and we want to defend our Amazon, since we are at a point of no return. We consider music to be a powerful and key tool; when the people are sad, when we feel alone, we perform ceremonies, rituals and we sing, to revive the faith of hope and ignite the fire in our hearts. That is why we have opted for music and we want to continue working with children, to defend everything we have in our Amazon.

BOX 34.6 Press and Communication

Sônia Bridi [originally in Portuguese, translated to English by Nathália Nascimento]

[Sônia Bridi is a journalist, writer and reporter on Brazilian television, at TV Rede Globo.]

A great future challenge is to repair a connection that began to be interrupted ten thousand years ago, our connection with nature. Since our species began to grow food, domesticate plants and animals, we began to build a gap between ourselves and the natural world; the more we urbanize, develop technology, change the landscape, the more the feeling grows that we are not part of nature and that we have the power to destroy and transform, we have a right to do so. This concept is widely propagated culturally and by some religions, some not all. For some we are the chosen species, for others the chosen people. Basically, it's the same thing, a sad contradiction that leads to worshiping the creator and massacring his creatures, such as plants, fungi, animals, or less favored Homo sapiens.

Box 34.6 *cont.*

How do we repair this dialogue? Communication plays a very important role; I'll start with the communication part that I work with. With few exceptions, it took journalists and documentarists a while to realize the importance of conservation in the media's agenda. Journalists who dedicated themselves to the subject over many years, in some newsrooms were seen as professionals who worked with smaller or less important topics. There has always been, and often still is, a more important agenda than the preservation of life on the planet. This is changing, but at a much slower pace than it needs to. We journalists and documentarians need to realize the urgency of the climate issue and the impact that the destruction of the Amazon has on accelerating this process, and that no topic, no subject, can be addressed today without considering the climate emergency. Urban planning, infrastructure engineering, transportation, education, resource use in offices or industry. The very planning of a reportage or documentary needs to take into account impact, mitigation, and compensation. The Amazon emergency has to be at the top of the checklist of any human activity, and we communicators need to make this clear to the public, explaining the causes and consequences, and offering information on available solutions. “I want to help, but I don't know how”; this is the comment I hear most from a public that is sensitive to information, but doesn't even know where to start, it's up to us communicators to present the paths that are being followed so that people can choose where to go.

On the other hand, we have entertainment, a great showcase of ideas, concepts, and visions of the world. Fiction has the power to transport us to alternative realities and can present us with a force that only literature and cinema carry, the worlds we can build. It can show total destruction of biodiversity and the conditions that allow it, or a more inclusive, restored world where we can enjoy all the amazing things this planet has to offer. We are the privileged ones of the known universe, and remembering that this wonderful biodiversity appeared here and only here as far as we know can have a brutal impact. Stop, look at the sky and think, here we are surrounded by color, water, plants, birds flying in the sky, and the rest of the known universe is monochromatic monotony, dry spots, totally devoid of life. We can't make Mars a planet like Earth, so why make Earth one more infertile rock in the universe?

Finally, I believe that the biggest challenge for all communicators, in any area, is to reestablish that broken connection. How? Showing the infinite beauty of this planet, the incredible complexity of the evolution of species, the co-evolution that makes one depend on the other and we on all of them, we need to go back to loving the natural world and we only love what we know. Only this can reverse the great contradiction of Homo sapiens.

We are defined by knowledge, we are destroying what we don't even know, denying knowledge that points out causes and solutions, and choosing ignorance over knowledge. We know that it is a very large component of denial caused by fear, but disseminating information is also fighting fear because there is nothing more frightening than the unknown. And it is to the unknown world full of dangers that we will walk if we lose this battle of information. The Amazon is the last great library of life that has not yet been read.

BOX 34.7 Spirituality

Manari Ushigua

[Manari Ushigua is a traditional healer and leader of the Sápara Nation in the Ecuadorian Amazon, of which there are less than 500 people remaining.]

I want to explain to you, the tropical forest has a way of making people understand and live their relationship with the tropical forest, because the tropical forest helps us dream and have clear visions to understand how we want to live, for those of us who live in the tropical forest. Facing this reality, the Amazonian city is situated on one path, as it is recognized. And those outside say that these provinces are developing and, therefore, they begin to destroy nature and there is a lot of livestock and the city itself suggests that this is the path of a development model that is not aimed at caring for nature; that is the difference that exists at the moment.

That said, we call ourselves Naku, the tropical forest, which has a way of teaching and a way of welcoming not only the Indigenous people who live in the tropical forest but anyone who visits has also experienced it; they feel that change. So, what the tropical forest gives us is a direction and a vision of life that the natural functioning, how they connect with each other and their life with the birds, right now among the trees.

That relationship and the relationship with the people who live there create an exact balance so that the people who sleep there and have a dream that we call Marquijauma, have an answer to any concern that we may have, so that with this answer we can live the material world. As such, for us the tropical forest is a space that we recognize as a sanctuary of knowledge, to be able to transmit from the tropical forest any question, any doubt that exists in the world, to give a positive answer, where people will understand where the future of humanity is heading.

So, the vision, for the people who live in the tropical forest, we do not only work from this reality, where it can be seen, from where it can be taken, from where it can be felt and that life is connected with the spiritual world. Whether through Marquijauma or not through dreams, we begin to project and understand what is being felt and lived. But seen from the spiritual world, we see our failures and it becomes aligned so that life is suitable, without diseases, without doubts, without complications, but rather its path is on the right track. That is what the tropical forest offers us, the Naku; for us there is only one world, or Kaji.

BOX 34.8 Sports
James Júnior

Hello, my name is James, I am an administrator and entrepreneur in the area of organizing sport events. (...)

Sports; we can split it into two feelings: the sport itself and the organization of sports events. Despite being connected, they have distinct moments, in which the event is a specific date, sometimes the goal to be achieved on this day and use the sport to be prepared on that day. And the sport itself, the practice, which is the daily activity, in which you practice, in which you execute, they move an enormous [market] chain, from companies that produce sports materials, in the food sector, also in the area of healthcare, such as physiotherapy, medicine, sports psychology, the production of materials such as sneakers, clothing, equipment, watches, compass, bicycles, etc.

All of this, to exist, needs that the nature environment is preserved, taken care of. And people when they practice sports, they start to create this feeling, you know, this bond of caring, this bond of investing, of wanting that that environment in which he/she participated is preserved so that he/she can participate again, so that he/she can have somewhere to practice, and that it is always in preserved conditions. And this preservation is not only to not devastate, but to not let it get dirty, to not let it get polluted and, mainly, understand the environment. It is the interactivity of understanding what can be extracted from there and how it works, how is the dynamics of its functionality, from the people who live in that environment, with all the animals, with all the plants that are there together. And sport helps to understand all of this, to create this relationship.

So, imagine that there is a distant community, already with few residents. What will make people reach this locality? Given that the concentration in the urban area is so high, it is the sport. Because there, the person will practice sports, so he/she will travel to this place, the person will know the place, the person will create feelings, and will invite new people to participate. That is, in his ever-growing relationship network, so that more people are together in this process of practicing sports. The person is swimming in the river, and he/she will want the river in swimming conditions, that is, the least polluted as possible, or even unpolluted. The person wants the environment where he/she will ride a bike, where he/she will run the trail, if the person will walk, or will practice any type of sport, abseiling or zipline, or adventure race that involves various types of sport, they are all together with nature. It helps the person to understand, to inform, to seek, to defend even after that experience, the maintenance of that environment.

So, I believe that sports, through sporting events, can be one of the main items to bring people back to nature, to make people have this relationship, this affectional bond, this care, this desire to know, this desire to be close to nature, to the forest, to care, to preserve, to understand the people who live in that place, and to encourage them to stay and, even, the remuneration for that.

BOX 34.9 Tourism

Pedro M. Nassar [originally in Portuguese, translated to English by Nathália Nascimento]

Hi everyone, I'm Pedro Nassar, I'm a biologist with Master's in Management of Protected Areas in the Amazon and I've been working with tourism for about 15 years. I've been in the Amazon for about 12 years and currently I work at the Mamirauá Sustainable Development Institute as coordinator of the community-based tourism program.

The other day I was reading a book by a French naturalist who passed through Brazil in the mid-19th century; this book specifically talked a little about the state of São Paulo, describing the vegetation, climate, and customs, and of the history of Brazil as it was understood at that time in the city of São Paulo. He also talked a little about the rivers, what the city was like at that time, and the fauna, a little bit about everything. I kept thinking how different São Paulo was at that time from what it is today. And that also made me take a trip to the present-day Amazon and think about the changes occurring. What is done in the past directly links to the future, and what we live today is the result of many things that were done years ago. What we are doing today will certainly change the destiny of generations to come, generations that haven't even been born yet.

When the Amazon is deforested, agriculture and livestock expand and take up space in the Amazon, mining causes deforestation, and this is concrete. The figurative distance between the city and natural areas increases and people have less and less contact with nature. This distance generates people who don't care much about nature. Because we tend to be more concerned, and to take better care of, what is close, since we have an affinity for what is there in our day-to-day. A change needs to be made, doesn't it? I believe it is possible, and a very interesting tool to reconnect the urban with the rural, to reconnect people to nature, to make people feel like a part of nature, is tourism. But not just any tourism. And tourism has to be done responsibly. Do you know what responsible tourism is? Responsible tourism thinks first from the point of view of the people who live there; it has to be a and good place for people to live. This makes it a good place, an interesting place, for visitors.

Responsible tourism (or sustainable tourism, rural tourism) must recognize the people who live in the place, the local population, as the protagonists. And they must be the main beneficiaries of socio-economic and environmental benefits. Those who visit will support this idea and spread it to their friends and family. Sustainable and responsible tourism has everything to do with the Amazon; shall we put this idea in everyone's head? Who will join me on this journey?

BOX 34.10 Visual Arts

Denilson Baniwa [originally in Portuguese, translated to English by Nathália Nascimento]

[Denilson Baniwa is a Brazilian artist, curator, designer, illustrator, Communicator, and indigenous rights activist.]

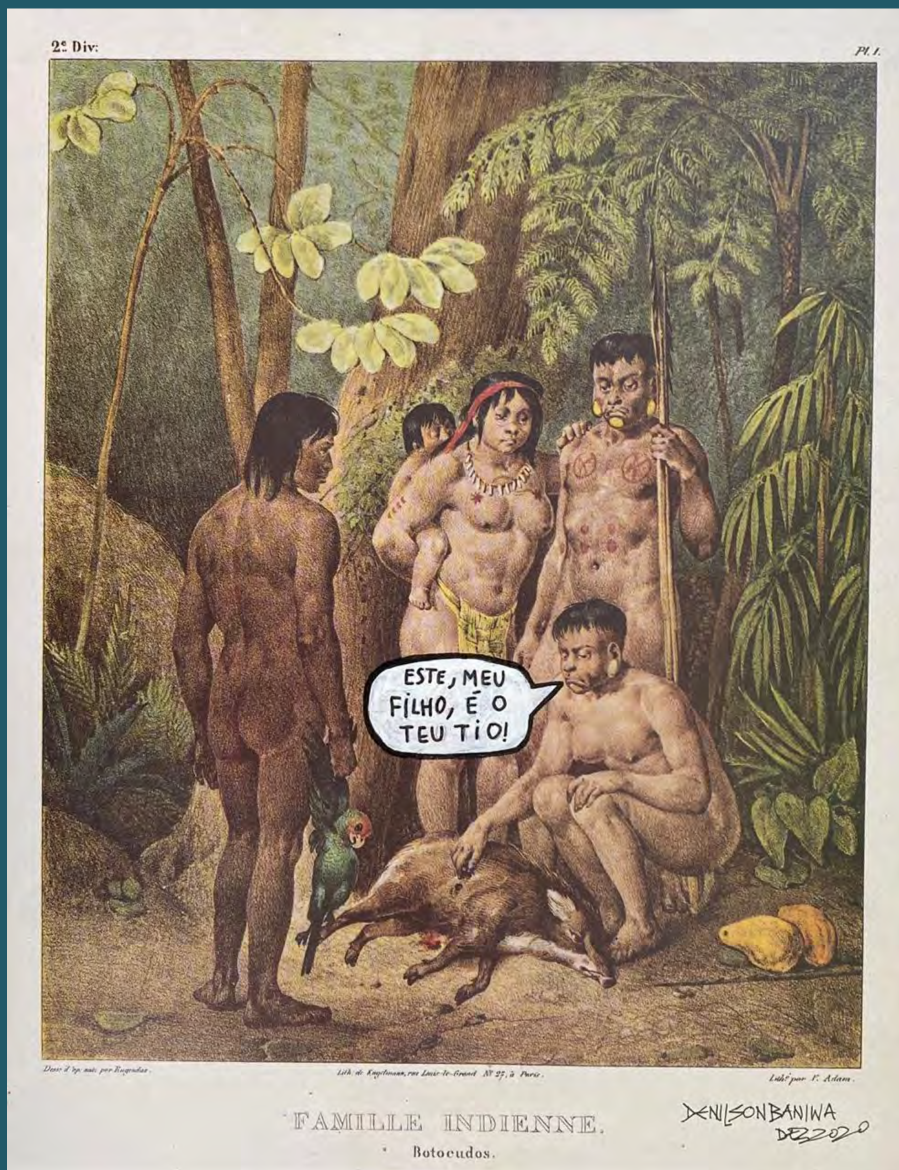


Figure 34.6 "Everything is people"; Denilson Baniwa, acrylic on photographic print, 32x24cm, Dec 2020.

Box 34.10 *cont.*

My grandparents say that in the old days
Before me, you or any other homo sapiens took over the planet
Everything was people: forest, humans and non-humans were people.
There were jaguar people, parrot people, tree people, stone people; and people-people
We all even spoke the same language. We understood each other.
The time was also different, there were no clocks or alarm clocks
Work was not an accumulating function, but a collective one.
But this was from a time that neither my grandparents nor we lived
It's from the time before time
Today we do not know the language of birds and plants
Of rocks, streams, and mountains we don't even remember anymore
We don't even understand each other with our neighbors and residents of the same planet.

I know well that at that time, we can't take it back
But we can today, learn the lost communication
When we start to think that there is an environment
Unlike us humans
In these times, while there is no time machine
That throws us back to the times of the ancestor world
We can come back to understand that we are part of the planet and not its dominant

Art, Indigenous or not, can serve as a metaphysical mechanism of translation
Translations of the voices of the forest, the stones, the water and all living beings
Indigenous art can be allied to the understanding of the worlds
For it, itself, transits between the ancestor and the plasticity of the modern world

Indigenous artists can be art-shamans who share
Knowledges brought from all voices
Including those we don't even remember existing anymore
Art is what unites us
It is the connection between the ancestral world and the world we want from now on.

production and urban green infrastructure without a new culture of urban planning in the Amazon. Or it can prove an easier task to promote a culture of sustainable tourism and sports within the forest if it is connected with improved healthcare assistance to forest- and river-dwellers.

Political, infrastructural, and financial incentives devoted to health, well-being, education, and technology sectors, with the conservation of forests and their biological and cultural assets being the key mechanism, could promote the desired reconnection between urban and rural societies and help secure a sustainable future for the region:

The physical proximity of food production units in rural areas to Amazonian cities is key for securing food. Food production in "peri-urban" areas could be a way forward for increasing producers' income, promoting forest conservation, and providing quality fresh food to the urban population, and Indigenous and traditional communities should be prioritized given their extensive expertise in staple agriculture in the region.

Subsidies and incentive programs to encourage long-term residency of healthcare professionals in small cities and rural settlements, as well as providing specialized equipment and installations to decentralize medical services. Additionally, to nurture, maintain, and rely on resources that are readily accessible to the local population (such as the SachaWarmi initiative in Ecuador).

The establishment of physical in-person education hubs in remote locations, aided by remote teaching technologies, and programs for training and encouraging the retention of teachers, preferably from the interior communities themselves.

Implementation of green infrastructure in the cities such as gardens, squares, urban forests, restoration of riparian forest, and other areas to minimize impacts from natural disasters (e.g., flooding). Infrastructure minimizes health and well-being costs in the long term and has the potential to generate numerous jobs, but it must be evenly distributed in the city to guarantee access for all.

Expansion of the smart forest technology to alert authorities about deforestation, logging, poaching, and smuggling activities. Additionally, remote sensing would help in *ex-situ* monitoring of forest flammability, industrial-scale tree planting for reforestation, or sharing touristic ecological information with urban population.

The cultural gaps between the Amazon forest and its people and the population inhabiting the increasingly globalized cities should be drastically narrowed through concerted interventions in different cultural sectors such as cinema, sports, and visual arts. Existing well-established rural–urban bonds such as food habits and traditional festivities can serve as good starting points to bring this cultural relation to another level.

Promoting these changes is an issue not only for policy makers but to society in general, from urban- to forest-dwellers, bearing in mind that the sustainability in the Amazon region is and will be shaped by its evolving urban network and its interaction with the rural and forest people and landscapes.

34.14 References

Adams C, Murrieta R, and Neves WA. 2006. Sociedades caboclas amazônicas: modernidade e invisibilidade. Annablume.

Alencar A, Pereira C, Castro I, *et al.* 2016. Desmatamento nos assentamentos da Amazônia: histórico, tendências e oportunidades. Brasília, DF: IPAM - Instituto de Pesquisa Ambiental da Amazônia,.

Alexiades MN. 1999. Ethnobotany of the Ese Eja: Plants, change and health in an Amazonian society. *Unpubl Dr Diss City Univ New York*.

Alexiades MN. 2009. Mobility and migration in Indigenous Amazonia: contemporary ethnoecological perspectives. Berghahn Books.

Alexiades MN and Lacaze D. 1996. FENAMADs program in traditional medicine: An integrated approach to health care in the Peruvian Amazon Balick , Michael J ., E . Elisabetsky and S . A . Laird, eds. Medicinal Resources of the Tropical Forest Biodiversity and its Importance to Human H

Alexiades MN and Peluso DM. 2015. Introduction: Indigenous urbanization in lowland South America.

Alexiades M and Peluso D. 2016. La urbanización indígena en la Amazonia. Un nuevo contexto de articulación social y territorial. Étnicas, Minorías Procesos D Eurbanos, Globalización y Contextos.

Alves L. 2020. Amazon fires coincide with increased respiratory illnesses in Indigenous populations. *Lancet Respir Med* **8**: e84.

Amato-Lourenço LF, Moreira TCL, Arantes BL de, *et al.* 2016. Metrópoles, cobertura vegetal, áreas verdes e saúde. *Estud Avançados* **30**: 113–30.

ANA. 2017. Atlas esgotos: despoluição de bacias hidrográficas. Brasília - DF.

Andrello G. 2006. Cidade do índio: transformações e cotidiano em Iauaretê. Editora Unesp.

Becker BK. 1991. Amazônia. São Paulo: Ed. Atica. *Principios*.

Becker B. 2013. A urbe amazônida (E Garamond, Ed). Rio de Janeiro.

Bertha B. 1985. Fronteira e urbanização repensadas. *Rev Bras Geogr* **47**: 357–71.

Bolle W, Castro E, and Vejmelka M. 2010. Amazônia: região universal e teatro do mundo. Globo.

Brenner N and Keil R. 2014. From global cities to globalized urbanization. *J Cult Polit Innov* **3**: 1–17.

Brondizio ES. 2016. The Elephant in the Room: Amazonian Cities Deserve More Attention in Climate Change and Sustainability Discussions. *Vulnerabilidade* **5**: 15–25.

Brondizio E. 2017. A Amazônia urbana é invisível. *Rev Pesqui Fapesp*.

Brondízio ES, Lima ACB de, Schramski S, and Adams C. 2016. Social and health dimensions of climate change in the Amazon. *Ann Hum Biol* **43**: 405–14.

Bunker SG. 2003. Matter, space, energy, and political economy: the Amazon in the world-system. *J world-systems Res* **9**: 219–58.

Burr V. 2015. Social constructionism. Routledge.
Castro DB de, Seixas Maciel EMG de, Sadahiro M, *et al.* 2018. Tuberculosis incidence inequalities and its social determinants in Manaus from 2007 to 2016. *Int J Equity Health* **17**: 1–10.
Cesco S and Lima E de FN de. 2018. "Terra da Promissão": recolonização e natureza na história amazônica. *Territ e Front* **11**: 123–51.
Colferai SA. 2013. Isolamento revisitado: o acesso à internet na Amazônia brasileira urbana. *Sessões do Imaginário* **18**: 36–42.
Confalonieri UEC. 2005. Saúde na Amazônia: um modelo conceitual para a análise de paisagens e doenças. *Estud Avançados* **19**: 221–36.
Côrtes JC and Silva Júnior RD da. 2021. A Interface entre Desmatamento e Urbanização na Amazônia Brasileira. *Ambient |& Soc* **24**.
Costa SMF da and Montoia GRM. 2020. PEQUENAS CIDADES DO DELTA. *Mercator* **19**: 1–14.
Cronkleton P, Albornoz MA, Barnes G, *et al.* 2010. Social Geomatics: Participatory Forest Mapping to Mediate Resource Conflict in the Bolivian Amazon. *Hum Ecol* **38**: 65–76.
Cunha MA and Fonseca Da Costa SM. Mapeamento da palmeira de açaí (Euterpe oleracea Mart.) na floresta Amazônica utilizando imagem de satélite de alta resolução espacial. *Rev Espinhaço* **2020**: 40–9.
Cunha MA, Przeybilovicz E, Macaya JFM, and Santos FBP dos. 2016. Smart cities: transformação digital de cidades.
Descola P. 2013. Beyond nature and culture. University of Chicago Press.
Diegues ACS, Millikan ECB, Ferraz IT, and Hebette J. 1997. Deforestation and livelihoods in the brazilian Amazon. NUPAUB, Research Center on Human Population and Wetlands, University of São~....
Falconí F, Ramos-Martin J, and Cango P. 2017. Caloric unequal exchange in Latin America and the Caribbean. *Ecol Econ* **134**: 140–9.
Farage N. 1991. As muralhas dos sertões: os povos indígenas no Rio Branco e a colonização. Paz e Terra.
Farage N and others. 1986. As Muralhas dos Sertões: os povos indígenas no Rio Branco e a colonização.
Frainer A, Mustonen T, Hugu S, *et al.* 2020. Opinion: Cultural and linguistic diversities are underappreciated pillars of biodiversity. *Proc Natl Acad Sci U S A* **117**: 26539–43.
Furtado WV dos S, Vaz Júnior OA, Veras AA de O, *et al.* 2020. Low-cost automation for artificial drying of cocoa beans: A case study in the Amazon. *Dry Technol*: 1–8.
Gabrys J. 2020. Smart forests and data practices: From the Internet of Trees to planetary governance. *Big Data |& Soc* **7**: 2053951720904871.
Gadelha RMAF. 2002. Conquista e ocupação da Amazônia: a fronteira Norte do Brasil. *Estud Avançados* **16**: 63–80.
Gorenflo LJ, Romaine S, Mittermeier RA, and Walker-Painemilla K. 2012. Co-occurrence of linguistic and biological diversity in biodiversity hotspots and high biodiversity wilderness areas. *Proc Natl Acad Sci* **109**: 8032–7.
Gracey M and King M. 2009. Indigenous health part 1: determinants and disease patterns. *Lancet* **374**: 65–75.
Higuchi MIG and Silva K. 2013. Entre a floresta e a cidade: percepção do espaço social de moradia em adolescentes. *Psicol para América Lat*: 5–23.
Huera-Lucero T, Salas-Ruiz A, Changoluisa D, and Bravo-Medina C. Towards Sustainable Urban Planning for Puyo (Ecuador): Amazon Forest Landscape as Potential Green Infrastructure.
IBGE. 2012. Censo Demográfico 2010: Características urbanísticas do entorno dos domicílioshttps://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=796. Viewed 17 Apr 2021.
IBGE. 2020. Acesso à internet e à televisão e posse de telefone móvel celular para uso pessoal 2018https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101705. Viewed
Irazábal C. 2009. Revisiting Urban Planning in Latin America and the Caribbean. *Glob Rep Hum Settlements*: 49.
Kambites C and Owen S. 2006. Renewed prospects for green infrastructure planning in the UK 1. *Plan Pract Res* **21**: 483–96.
Kohn E. 2013. How forests think: Toward an anthropology beyond the human. Univ of California Press.
Kroeger A. 1983. Anthropological and socio-medical health care research in developing countries. *Soc Sci |& Med* **17**: 147–61.
Kroeger A and Barbira-Freedman F. 1992. La lucha por la salud en el Alto Amazonas y en los Andes.
Lapola DM, Braga DR, Giulio GM Di, *et al.* 2019. Heat stress vulnerability and risk at the (super) local scale in six Brazilian capitals. *Clim Change* **154**: 477–92.
Lapola DM, Pinho P, Quesada CA, *et al.* 2018. Limiting the high impacts of Amazon forest dieback with no-regrets science and policy action. *Proc Natl Acad Sci* **115**: 11671–9.
Lefebvre H. 2003. The urban revolution. U of Minnesota Press.
Levis C, Costa FRC, Bongers F, *et al.* 2017. Persistent effects of pre-Columbian plant domestication on Amazonian forest composition. *Science (80-)* **355**: 925–31.
Liebert MA, Snodgrass JJ, Madimenos FC, *et al.* 2013. Implications of market integration for cardiovascular and metabolic health among an Indigenous Amazonian Ecuadorian population. *Ann Hum Biol* **40**: 228–42.
Lima E de FN de. 2012. O rural na história. Euclides Da Cunha, José Veríssimo e Ferreira De Castro. *Ra{\'\i}zes Rev Ciências Sociais e Econômicas* **32**: 122–38.
Machado FSN, Carvalho MAP de, Mataresi A, *et al.* 2010. Use of telemedicine technology as a strategy to promote health care of riverside communities in the Amazon: experience with interdisciplinary work, integrating NHS guidelines. *Cienc |& saude coletiva* **15**: 247.
Maffi L. 2010. What is Biocultural Diversity? In: Maffi, L. and Woodley E (Ed). Biocultural diversity conservation: a global sourcebook. Washington D.C.: Earthscan.
Maffi L and Woodley E. 2012. Biocultural diversity conservation: a global sourcebook.
Mansur A V, Brond\'\izio ES, Roy S, *et al.* 2016. An assessment of urban vulnerability in the Amazon Delta and Estuary: a multi-criterion index of flood exposure, socio-economic conditions and infrastructure. *Sustain Sci* **11**: 625–43.
Medeiros C. 2020. Tim afirma que queimadas estão afetando sinal de internet no Amazonas. *A Crítica*.
Nagabhatla N, Springgay E, Dudley N, and others. 2018. Forests

as nature-based solutions for ensuring urban water security. *Unasylva* **250**: 43–52.
Norton BA, Coutts AM, Livesley SJ, *et al.* 2015. Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. *Landsc Urban Plan* **134**: 127–38.
Oliveira LL. 1998. A conquista do espaço: sertão e fronteira no pensamento brasileiro. *História, ciências, saúde-Manguinhos* **5**: 195–215.
Oliveira G de, Chen JM, Stark SC, *et al.* 2020. Smoke pollution's impacts in Amazonia (J Sills, Ed). *Science (80-)* **369**: 634.2-635.
Oliveira GF, Oliveira TR, Rodrigues FF, *et al.* 2011. Prevalence of diabetes mellitus and impaired glucose tolerance in Indigenous people from Aldeia Jaguapiru, Brazil. *Rev Panam Salud Pública* **29**: 315–21.
Padoch C, Brondizio E, Costa S, *et al.* 2008. Urban forest and rural cities: multi-sited households, consumption patterns, and forest resources in Amazonia. *Ecol Soc* **13**.
Pauleit S, Liu L, Ahern J, and Kazmierczak A. 2011. Multifunctional Green Infrastructure Planning to Promote Ecological Services in the City. In: Urban Ecology. Oxford University Press.
Peluso DM. 2015. Circulating between rural and urban communities: Multisited dwellings in Amazonian frontiers. *J Lat Am Caribb Anthropol* **20**: 57–79.
Peluso D. 2018. Traversing the margins of corruption amidst informal economies in Amazonia. *Cult Theory Crit* **59**: 400–18.
Peluso DM. 2020. Gendered geographies of care: women as health workers in an Indigenous health project in the Peruvian Amazon. *Tipití J Soc Anthropol Lowl South Am*.
Peluso DM and Alexiades M. 2005. Urban ethnogenesis begins at home: The making of self and place amidst Amazonia's environmental economy. *Tradit Dwellings Settlements Rev* **16**: 1–10.
Pickett STA, Boone CG, McGrath BP, *et al.* 2013. Ecological science and transformation to the sustainable city. *Cities* **32**: S10–20.
Pinto E de PP, Souza ML de L, Cardoso AM, *et al.* 2020. Assentamentos Sustentáveis na Amazônia: o desafio da produção familiar em uma economia de baixo carbono. *Investimentos Transform para um estilo Desenvolv sustentável Estud casos Gd Impuls (Big Push) para a sustentabilidade no Bras Bras CEPAL, 2020 LC/TS 2020/37 p 89-102*.
Piperata BA, Spence JE, Da-Gloria P, and Hubbe M. 2011. The nutrition transition in Amazonia: rapid economic change and its impact on growth and development in Ribeirinhos. *Am J Phys Anthropol* **146**: 1–13.
Pope F. 2020. Querida Amazonia - Post-synodal exhortation of the holy father Francis to the people of God and to all persons of goog will. : 88.
Porter-Bolland L, Ellis EA, Guariguata MR, *et al.* 2012. Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *For Ecol Manage* **268**: 6–17.
Prebisch R. 1962. The economic development of Latin America and its principal problems. *Econ Bull Lat Am*.
PRODES — Coordenação-Geral de Observação da Terra.http://www.obt.inpe.br/OBT/assuntos/programas/amazonia/prodes. Viewed 27 Mar 2021.
Raminelli R. 1994. Da vila ao sertão: os mamelucos como agentes da colonização. *Rev Hist (Costa Rica)*: 209–19.
Raymond CM, Frantzeskaki N, Kabisch N, *et al.* 2017. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environ Sci Policy* **77**: 15–24.
Salisbury DS and Fagan C. 2013. Coca and conservation: cultivation, eradication, and trafficking in the Amazon borderlands. *GeoJournal* **78**: 41–60.
Sassen S and others. 2002. Global networks, linked cities. Psychology Press.
Schor T, Azenha GS, and Bartoli E. 2018. Contemporary urbanization in the Brazilian Amazon: food markets, multisited households and ribeirinho livelihoods. *Confins*.
Schor T, Tavares-Pinto MA, Avelino FC da C, and Ribeiro ML. 2015. Do peixe com farinha à macarronada com frango: uma análise das transformações na rede urbana no Alto Solimões pela perspectiva dos padrões alimentares. *Confins*.
Sevcenko N. 1996. O front brasileiro na guerra verde: vegetais, colonialismo e cultura. *Rev Usp*: 108–19.
Sheller M and Urry J. 2016. Mobilizing the new mobilities paradigm. *Appl Mobilities* **1**: 10–25.
Silveira RP and Pinheiro R. 2014. Entendendo a necessidade de médicos no interior da Amazônia - Brasil. *Rev Bras Educ Med* **38**: 451–9.
Simmel G. 1997. A metrópole e a vida do espírito. *Cid Cult e Glob ensaios Sociol Oeiras Celta*: 31–43.
Simmel G. 2005. As grandes cidades e a vida do espírito (1903). *Mana* **11**: 577–91.
Souza M and Alencar A. 2020. Assentamentos Sustentáveis na Amazônia: Agricultura Familiar e Sustentabilidade Ambiental na Maior Floresta Tropical do Mundo.
Souza Filho ZA de, Ferreira AA, Santos J Dos, *et al.* 2018. Cardiovascular risk factors with an emphasis on hypertension in the Mura Indians from Amazonia. *BMC Public Health* **18**: 1–12.
Steege H ter, Prado PI, Lima RAF de, *et al.* 2020. Biased-corrected richness estimates for the Amazonian tree flora. *Sci Rep* **10**: 10130.
Tourneau FM Le and Bursztyn M. 2010. Assentamentos rurais na Amazônia: Contradições entre a política agrária e a política ambiental. *Ambient e Soc* **13**: 111–30.
Tregidgo DJ, Barlow J, Pompeu PS, *et al.* 2017. Rainforest metropolis casts 1,000-km defaunation shadow. *Proc Natl Acad Sci* **114**: 8655–9.
Trindade S-CC da. 2013. Uma Floresta Urbanizada? Legado e Desdobramentos de uma Teoria sobre o Significado da Cidade e do Urbano na Amazônia. *Espaço Aberto* **3**: 89–108.
Tzoulas K, Korpela K, Venn S, *et al.* 2007. Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landsc Urban Plan* **81**: 167–78.
UNIVAP. Fotos | Laboratório Cidadeshttps://www.labcidadesunivap.net/fotoslabcidades. Viewed 16 Apr 2021.
Vieira TA and Panagopoulos T. 2020. Urban Forestry in Brazilian Amazonia. *Sustainability* **12**: 3235.

CONTACT INFORMATION

SPA Technical-Scientific Secretariat New York
475 Riverside Drive, Suite 530
New York NY 10115
USA
+1 (212) 870-3920
spa@unsdsn.org

SPA Technical-Scientific Secretariat South America
Av. Ironman Victor Garrido, 623
São José dos Campos – São Paulo
Brazil
spasouthamerica@unsdsn.org

WEBSITE theamazonwewant.org
INSTAGRAM @theamazonwewant
TWITTER @theamazonwewant