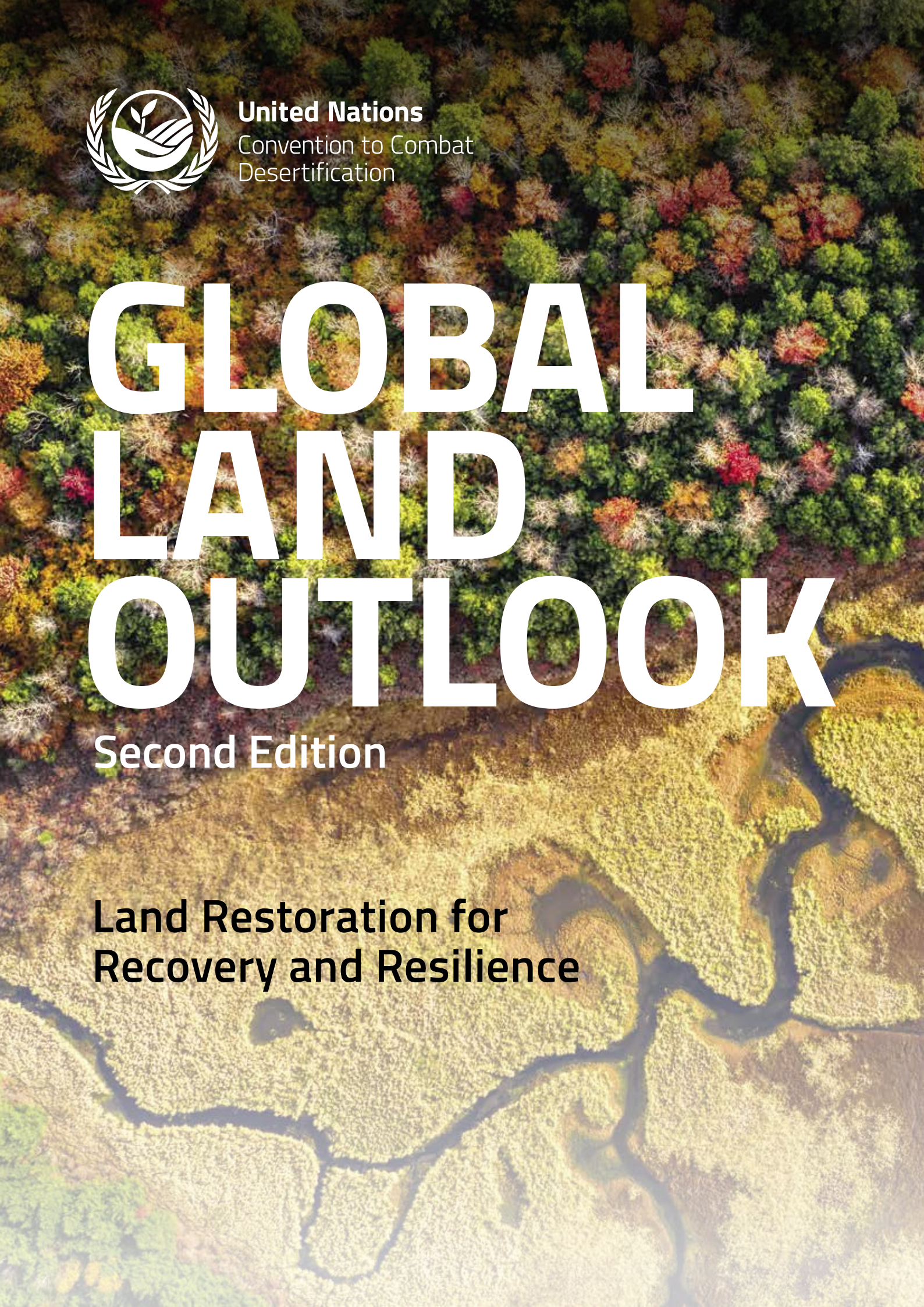


United Nations
Convention to Combat Desertification

GLOBAL LAND OUTLOOK

Second Edition

Land Restoration for Recovery and Resilience

United Nations
Convention to Combat Desertification

The objective of the United Nations Convention to Combat Desertification (UNCCD) is to support countries and communities with the rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions. With 197 Parties, the UNCCD unites decision makers, scientists, civil society and the private sector around a shared vision and framework for action to transform how land resources are used and managed to ensure healthy lives and sustainable livelihoods.

Supporting Partners

산림청 Korea Forest Service

THE CHANGWON INITIATIVE

China Combating Desertification

ankara initiative

Government of the Netherlands

Contributing Partners

C4 EcoSolutions
CARBON | CONSERVATION | CLIMATE | COMMUNITY

CIFOR

CILSS

Convention on Biological Diversity

FIG International Federation of Surveyors
Fédération Internationale des Géomètres
Internationale Vereinigung der Vermessungsingenieure

Food and Agriculture Organization of the United Nations

Global LAND Project

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ICLEI Local Governments for Sustainability

PBL Netherlands Environmental Assessment Agency

SER SOCIETY FOR ECOLOGICAL RESTORATION

UNDP

UN environment programme

UN-HABITAT FOR A BETTER URBAN FUTURE

Wetlands INTERNATIONAL

World Agroforestry

GLOBAL LAND OUTLOOK

Second Edition

Land Restoration for Recovery and Resilience

©jay-mantri-unsplash

CONTENTS

ACKNOWLEDGMENTS

The second edition of the Global Land Outlook (GLO2) was the product of a team effort led by the UNCCD secretariat and the GLO2 steering committee, in collaboration with supporting and contributing partners, and in consultation with key stakeholders and experts. Eight working papers were commissioned to provide insights and analysis on the major themes addressed in GLO2, subtitled *Land Restoration for Recovery and Resilience*.

Global Land Outlook Team

Co-Coordinators: Clarissa Augustinus and Sasha Alexander

Co-Editors: Clarissa Augustinus, Jon Cox, and Sasha Alexander

Research: Paul Schmidt, Marloes Bakker, Vittoria Semplici, Paul Mundy, Corinna Voigt

Design and Layout: QUO Bangkok

Copy Editing: Mark Schulman

Steering Committee Members

Manon Albagnac (UNCCD CSO Panel), Issifou Alfari (CILSS), Jamal Annagylyjova (CBD), Nichole Barger (UNCCD-SPI), Ermias Betemariam (UNCCD-SPI), Christopher Bren d'Amour (GIZ), Marc Dawson (SERVIR), George Gann (SER), Manuel Guariguata (CIFOR), Lisa Janishevski (CBD), Anne Juepner (UNDP), Elie Kodsi (UNDP), Rachel Kosse (UNEP), Samuel Mabikke (FAO), Anthony Mills (C4ES), Paul Munro-Faure (FIG), Everlyne Nairesiae (UN Habitat), Casey Ryan (GLP), Pourya Salehi (ICLEI), Annelies Sewell (PBL), Hans Shutten (WI), Elke Stehfest (PBL), Stefan van der Esch (PBL), Graham von Maltitz (UNCCD-SPI), Leigh Winowiecki (ICRAF), Daowei Zhang (Auburn University), Feras Ziadat (FAO).

UNCCD Science-Policy Interface (SPI)

As mandated by the Conference of the Parties, the SPI assumed a primary role in providing quality assurance for GLO2, which included participation on the steering committee, extensive scientific review of all elements and drafts, and approval of the final report and summary for decision makers. SPI members also contributed to the review of the GLO2 working papers.

External Reviewers

James Aronson (EcoHealth Network), Laura Cerasi (CMS), Antonio Q"Apaj Conde Choque (CBD), David Cooper (CBD), Monica Visalam Iyer (OHCHR), Tanya Mcgregor (CBD), Edjigayehu Seyoum (CBD).

SPI members: Felicia O. Akinyemi (University of Bern), Vera Boerger (FAO), Xiangzheng Deng (Chinese Academy of Sciences), Helene Gichenje (University of Evora), Caroline King-Okumu (Centre for Ecology and Hydrology), Rattan Lal (Ohio State University), Anna Luise (Italy), André Francisco Pilon (University of Sao Paulo), NH Ravindranath (Indian Institute of Science).

UNCCD national focal points: Imad Almaree (Syria), Carlos Abel Cifuentes Figueroa (Guatemala), Andrei Kuzmich (Belarus), Qu (China), Angelo Paulo Sales dos Santos (Brazil).

Restoration Commitments and Scenarios

Goals and Commitments for the Restoration Decade: A global overview of countries' restoration commitments under the Rio Conventions and other pledges © PBL Netherlands Environmental Assessment Agency, The Hague, 2020. PBL publication number: 3906.
https://www.pbl.nl/en/publications/goals-and-commitments-for-the-restoration-decade

The global potential for land restoration: Scenarios for the Global Land Outlook 2 © PBL Netherlands Environmental Assessment Agency, The Hague, 2021. PBL publication number: 3898.
https://www.pbl.nl/en/publications/the-global-potential-for-land-restoration-scenarios-for-the-global-land-outlook-2

Working Paper Authors

Eugene Chigbu (Land Tenure), Heather Elaydi (Food Systems), Thomas Forster (Urban-Rural Linkages), Baris Karapinar (COVID-19 Recovery), Sandra Kemeh (Youth Engagement), Evelyn Namabiru (Gender Responsiveness), Adam Prakash (Perverse Incentives), Gary Tabor (Ecological Connectivity).

Working Paper Reviewers

Marcos Montoiro (UNCCD), Enni Kallio (UNCCD), Corinna Voigt (UNCCD), Morgane Chiocchia (UNCCD), Sandrine Jauffret (UNCCD), Pablo Munoz (UNCCD), Pourya Salehi (ICLEI), Anthony Mills (C4ES), Mark Schauer (GIZ), Waltraud Ederer (GIZ), Vanja Westerberg (GIZ), Thomas Forster (Practice2Policy), Joseph Schechla (Housing and Land Rights Network), Vittoria Semplici (UNCCD), Laura Cerasi (CMS), Barron Joseph Orr (UNCCD).

Special Thanks

The GLO2 team would like to acknowledge the support and guidance of the UNCCD's Executive Secretary, Ibrahim Thiaw. This second edition was produced with the generous financial support provided by the Governments of the Republic of Korea, the Peoples' Republic of China, the Republic of Türkiye, the Kingdom of the Netherlands, and the European Union.

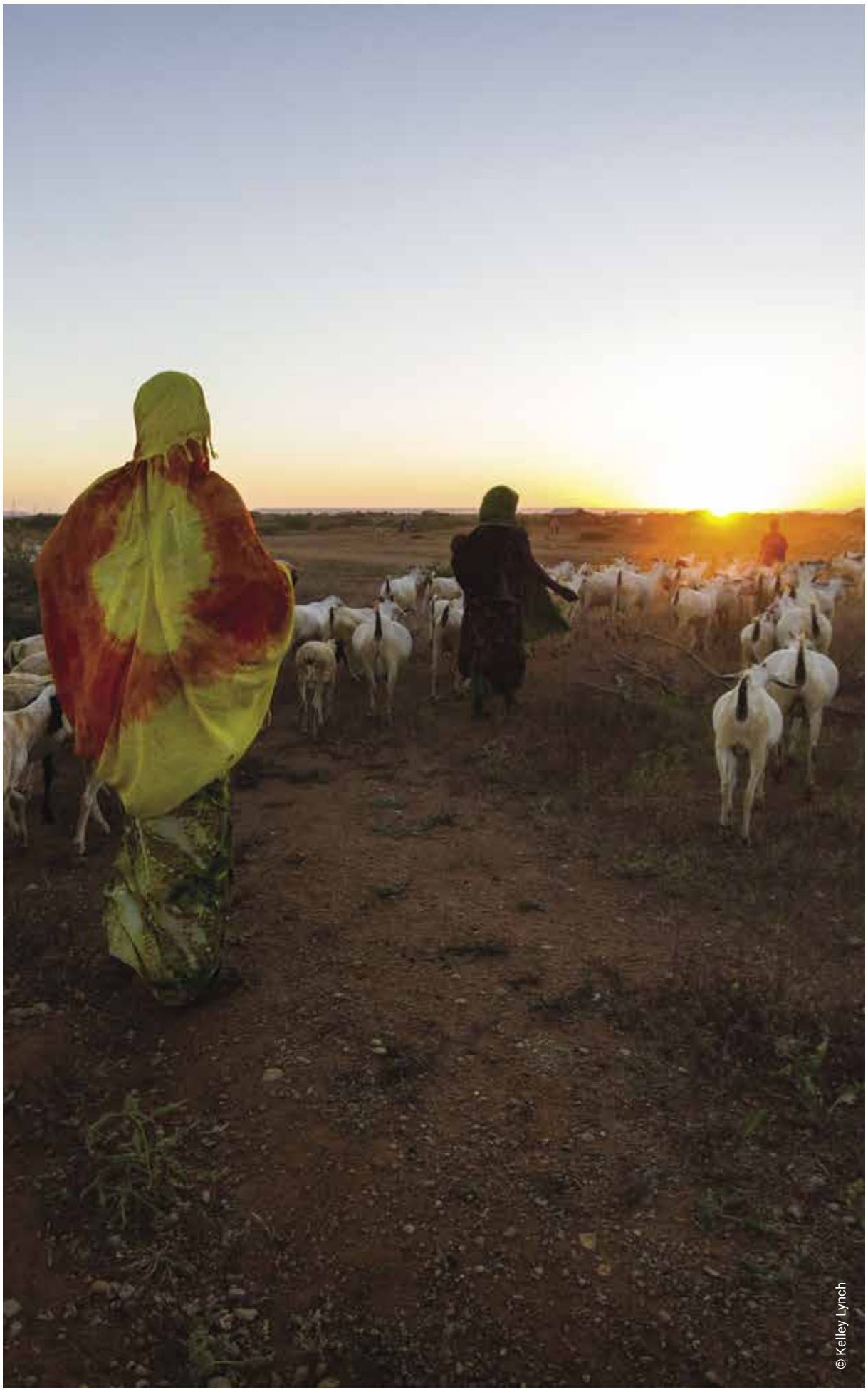
Disclaimer

For more information on the UNCCD and GLO products, please visit
https://www.unccd.int/resources/global-land-outlook/overview

Citation: United Nations Convention to Combat Desertification, 2022. The Global Land Outlook, second edition. UNCCD, Bonn.

ISBN: 978-92-95118-53-9
eISBN: 978-92-95118-52-2

Cover Photo: ©cameron-venti-unsplash


© Kelley Lynch

FOREWORD

Ibrahim Thiaw
Executive Secretary
United Nations
Convention to Combat
Desertification

In a world of profligate consumerism, global supply chains, and a growing population, land resources – our soil, water, and biodiversity – are rapidly being depleted. As a finite resource and our most valuable natural asset, we can no longer afford to take land for granted. We must move to a crisis footing to address the challenge and make land the focus.

Land restoration aims to reverse land degradation through a variety of activities that revitalize our soil, watersheds, and natural ecosystems. It is no longer enough to prevent further damage to the land; it is necessary to act decisively to reverse and recover what we have lost. Restoration also prepares us for an uncertain future. Regenerating our land resources provides multiple benefits for people, climate, and nature in the form of improved food security and human health, meaningful green jobs, and drought resilience, just to name a few.

Land Degradation Neutrality (LDN) is at the heart of the land restoration agenda, providing a practical framework and flexible planning tools for the sustainable management of our land and water systems. More than 130 countries have adopted LDN targets to avoid the future loss of land-based natural capital by scaling up sound stewardship and restoration practices.

We cannot stop the climate crisis today, biodiversity loss tomorrow, and land degradation the day after. We need to tackle all these issues together. Land restoration is integral to joint efforts under the Rio Conventions and other international agreements that are essential to make meaningful progress towards the Sustainable Development Goals. The year 2021 marked the beginning of the UN Decade on Ecosystem Restoration. This will help galvanize our efforts and increase the momentum to reimagine, recharge, and restore a healthy balance with the natural world.

The condition of land affects everyone, so caring for it is our shared responsibility. That is why the UNCCD unites diverse stakeholders – governments, scientists, farmers, private sector, and local communities – to support targeted initiatives that protect and restore land health and productivity. Using collaborative and evidence-based approaches, we support countries with the knowledge and tools they need to increase drought resilience, prevent future disasters, and enact more responsible land governance that empowers women and youth, indigenous peoples and local communities.

I am therefore delighted to present the second edition of the Global Land Outlook on *Land Restoration for Recovery and Resilience*. This edition of the UNCCD's flagship publication is a timely report offering a compelling rationale to inspire us all to take action to address multiple crises of our own making. It provides a suite of flexible pathways for countries and communities to design and implement their unique land restoration agenda. Never have these pathways to a safer, just, and more sustainable future been so clearly mapped for the world to see. The solution is right beneath our feet.

KEY MESSAGES

1. Land in the Balance

1.1 Land resources – soil, water, and biodiversity – provide the foundation for the wealth of our societies and economies. They meet the growing needs and desires for food, water, fuel, and other raw materials that shape our livelihoods and lifestyles. However, the way we currently manage and use these natural resources is threatening the health and continued survival of many species on Earth, including our own.

1.2 Of nine planetary boundaries used to define a 'safe operating space for humanity', four have already been exceeded: climate change, biodiversity loss, land use change, and geochemical cycles.[1] These breaches are directly linked to human-induced desertification, land degradation, and drought. If current trends persist, the risk of widespread, abrupt, or irreversible environmental changes will grow.[2]

1.3 Roughly USD 44 trillion of economic output – more than half of global annual GDP – is moderately or highly reliant on natural capital.[3] Yet governments, markets, and societies rarely account for the true value of all nature's services that underpin human and environmental health. These include climate and water regulation, disease and pest control, waste decomposition and air purification, as well as recreation and cultural amenities.[4]

2. Moving to a Crisis Footing

2.1 The world is facing a confluence of unprecedented crises: the fast-moving COVID-19 pandemic has merged with the ongoing and relentless global changes to our climate, land, and biodiversity. Collectively, these are causing extraordinary levels of human suffering, social and economic instability, and environmental devastation. Conserving, restoring, and using our land resources sustainably is a global imperative: one that requires moving to a crisis footing.

2.2 At no other point in modern history has humanity faced such an array of familiar and unfamiliar risks and hazards, interacting in a hyper-connected and rapidly changing world.[5] We cannot afford to underestimate the scale and impact of these existential threats. Rather we must work to motivate and enable all stakeholders to go beyond existing development and business models to activate a restorative agenda for people, nature, and the climate.

2.3 Land restoration is essential and urgently needed. It must be integrated with allied measures to meet future energy needs while drastically reducing greenhouse gas emissions; address food insecurity and water scarcity while shifting to more sustainable production and consumption; and accelerate a transition to a regenerative, circular economy that reduces waste and pollution.

3. Setting the Agenda

3.1 The international community has pledged to restore one billion hectares of degraded land by 2030. This is only the start. The aim is to preserve nature's life-support services and safeguard the productivity of land resources for generations to come, reduce the risks and impacts of disasters and pandemics, and boost ecosystem and community resilience in the face of impending environmental stresses and climate shocks.

3.2 Restoration is a proven and cost-effective solution to help reverse climate change and biodiversity loss caused by the rapid depletion of our finite natural capital stocks. Land restoration is broadly understood as a continuum of sustainable land and water management practices that can be applied to conserve or 'rewild' natural areas, 'up-scale' nature-positive food production in rural landscapes, and 'green' urban areas, infrastructure, and supply chains.[6]

3.3 The land restoration agenda is a multiple benefits strategy that reverses past land and ecosystem degradation while creating opportunities that improve livelihoods and prepare us for future challenges. For example, regenerative land use practices employed to boost soil health or recharge groundwater also enhance our ability to cope with drought, floods, wildfires, and sand and dust storms.

4. Making Land the Focus

4.1 Land is the operative link between biodiversity loss and climate change, and therefore must be the primary focus of any meaningful intervention to tackle these intertwined crises. Restoring degraded land and soil provides the most fertile ground on which to take immediate and concerted action.

4.2 Land and ecosystem restoration will help slow global warming, reduce the risk, scale, frequency, and intensity of disasters (e.g., pandemics, drought, floods), and facilitate the recovery of critical biodiversity habitat and ecological connectivity to avoid extinctions and restore the unimpeded movement of species and the flow of natural processes that sustain life on Earth.

4.3 Restoration is needed in the right places and at the right scales to better manage interconnected global emergencies. Responsible governance and land use planning will be key to protecting healthy and productive land and recuperating biodiverse, carbon-rich ecosystems to avoid dangerous tipping points.

5. Transforming Food Systems

5.1 Modern agriculture has altered the face of the planet more than any other human activity – from the production of food, animal feed, and other commodities to the markets and supply chains that connect producers to consumers. Making our food systems sustainable and resilient would be a significant contribution to the success of the global land, biodiversity, and climate agendas.

5.2 Globally, food systems are responsible for 80% of deforestation, 70% of freshwater use, and are the single greatest cause of terrestrial biodiversity loss.[7] [8] At the same time, soil health and biodiversity below ground – the source of almost all our food calories – has been largely neglected by the industrial agricultural revolution of the last century.

5.3 Intensive monocultures and the destruction of forests and other ecosystems for food and commodity production generate the bulk of carbon emissions associated with land use change.[9] Nitrous oxides from fertilizer use and methane emitted by ruminant livestock comprise the largest and most potent share of agricultural greenhouse gas emissions.[10]

6. Putting People Front and Center

6.1 Land restoration is about creating sustainable livelihood opportunities for people – small-scale farmers, indigenous peoples and local communities, businesses and entrepreneurs, women and youth – to boost incomes, secure food and water supplies, and make individuals and communities less vulnerable.

6.2 Top-down solutions to avoid or reduce land degradation and water scarcity are unlikely to succeed without bottom-up stakeholder engagement and the security of land tenure and resource rights. At the same time, trusted institutions and networks are needed to help build bridges that bring together different forms of capital to restore land health and create dignified jobs.

6.3 More inclusive and responsible governance can facilitate the shift to sustainable land use and management practices by building human and social capital. Increased transparency and accountability are prerequisites for integrated land use planning and other administrative tools that can help deliver multiple benefits at various scales while managing competing demands.

7. Safeguarding Land Rights

7.1 Land restoration provides unique entry points to apply human rights-based approaches that improve natural resource use and environmental management, especially when they are linked to existing national commitments under international treaties and agreements.

7.2 In 2019, the UNCCD adopted a decision which "invites Parties to ensure that measures to combat desertification, land degradation, and drought are carried out in a non-discriminatory and participatory way so that they promote equal tenure rights and access to land for all, in particular vulnerable and marginal groups".[11]

7.3 In 2021, the UN Human Rights Council adopted a resolution that "calls upon all States to conserve, protect and restore healthy ecosystems and biodiversity and to ensure their sustainable management and use by applying a human rights-based approach that emphasizes participation, inclusion, transparency, and accountability in natural resource management".[12]

8. Redirecting Investment and Incentives

8.1 Redirecting public spending towards regenerative land management solutions offers a significant opportunity to align private sector investment with longer-term societal goals – not only for food, fuel, and raw materials, but also for green and blue infrastructure for drought and flood mitigation, renewable energy provision, biodiversity conservation, and water and waste recycling.

8.2 Territorial and landscape approaches can leverage public and private financing for large-scale or multi-sector restoration initiatives by allowing diverse groups of stakeholders to establish partnerships that pool resources, aggregate project activities, and share costs. These collaborative approaches will make land restoration initiatives more effective and attractive to donors and investors.

8.3 It is unrealistic to expect developing countries to cover the entire bill for a 'just transition' to a restoration economy and climate-resilient future. Extra-budgetary support will be needed – from corporate investment, climate finance, debt relief, and donor/development aid to a range of innovative financial instruments that explicitly include environmental, social, and governance criteria.

9. Working Together to Restore Land

9.1 The stark implications of the business-as-usual scenario means that decisive action at all levels and from all actors is needed to realize the promise of the restoration scenarios contained in this Outlook.[13] What is clear and unequivocal is the need for coordinated measures to meaningfully slow or reverse climate change, land degradation, and biodiversity loss to safeguard human health and livelihoods, ensure food and water security, and leave a sustainable legacy for future generations.

9.2 The United Nations, acting as one, has a unique capacity to motivate the global community, stimulate a worldwide movement, and help secure finance for land restoration at scale. With its convening power, the UN can help build the evidence base needed to assist countries in creating incentives that shift attitudes and behavior towards regenerative, climate-resilient, and nature-positive solutions.

9.3 The UN General Assembly has affirmed that combating desertification, land degradation, and drought – and achieving Land Degradation Neutrality (LDN) – is an effective pathway to accelerate progress towards achieving multiple Sustainable Development Goals by 2030.[14] The UNCCD and many global partners are championing the land restoration agenda, using a wide range of evidence-based strategies and practices that can be tailored to local contexts and replicated at multiple scales.

10. Activating the Land Restoration Agenda

10.1 Ambitious land restoration targets must be backed by clear action plans and sustained financing. Countries that are disproportionately responsible for the climate, biodiversity, and environmental crises must do more to support developing countries as they restore their land resources and make these activities central to building healthier and more resilient societies.[15]

10.2 The UN Decade on Ecosystem Restoration is galvanizing indigenous peoples and local communities, governments, the private sector, and civil society as part of a global movement to undertake all types of restoration, across all scales, marshalling all possible resources. This powerful 10-year ambition aims to transform land and water management practices to meet the demands of the 21st century while eradicating poverty, hunger, and malnutrition.

10.3 Land restoration is a shared responsibility – everyone has a role to play because everyone has a stake in the future. Governments, businesses, and communities can restore together by seeking convergence and complementarity. Environmental and development priorities can be responsibly managed to create a healthier and more sustainable mosaic of land uses without compromising needs and aspirations of current and future generations.

ENDNOTES

1 Raworth, K., 2017. The doughnut of social and planetary boundaries. Doughnut Economics Action Lab. https://doughnuteconomics.org/about-doughnut-economics

2 Rockström, J., Beringer, T., Hole, D., Griscom, B., Mascia, M.B., Folke, C. and Creutzig, F., 2021. Opinion: We need biosphere stewardship that protects carbon sinks and builds resilience. Proceedings of the National Academy of Sciences, 118(38). https://www.pnas.org/content/pnas/118/38/e2115218118.full.pdf

3 WEF, 2020. Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy. New Nature Economy series, Geneva. https://www.weforum.org/reports/nature-risk-rising-why-the-crisis-engulfing-nature-matters-for-business-and-the-economy

4 Dasgupta, P., 2021. The Economics of Biodiversity: The Dasgupta Review. London: HM Treasury. https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

5 FAO, 2021. The impact of disasters and crises on agriculture and food security, Rome. https://www.fao.org/3/cb3673en/cb3673en.pdf

6 Gann, G.D., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson, J., Hallett, J.G., Eisenberg, C., Guariguata, M.R., Liu, J. and Hua, F., 2019. International principles and standards for the practice of ecological restoration. Restoration Ecology. 27 (S1): S1-S46. https://onlinelibrary.wiley.com/doi/10.1111/rec.13035

7 WWF, 2020. Living Planet Report. https://livingplanet.panda.org

8 Chatham House, 2021. Food systems Impacts on biodiversity loss. https://www.chathamhouse.org/2021/02/food-system-impacts-biodiversity-loss

9 IPCC, 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 11. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter11.pdf

10 Lynch, J., Cain, M., Frame, D. and Pierrehumbert, R., 2021. Agriculture's contribution to climate change and role in mitigation is distinct from predominantly fossil CO2-emitting sectors. Frontiers in sustainable food systems, 4, p.300. https://www.frontiersin.org/articles/10.3389/fsufs.2020.518039/full

11 UNCCD, 2019. Decision 26/COP.14 on Land tenure. Decision adopted at the 14th meeting of the Conference of the Parties on 13 September 2019. https://www.unccd.int/sites/default/files/sessions/documents/2019-11/26-cop14.pdf

12 UN Human Rights Council, 2021. Human rights and the environment. A/HRC/46/7. Resolution adopted by the Human Rights Council on 23 March 2021. https://undocs.org/A/HRC/RES/46/7

13 PBL, 2021. The global potential for land restoration: Scenarios for the Global Land Outlook 2. PBL Netherlands Environmental Assessment Agency, The Hague. https://www.pbl.nl/en/publications/the-global-potential-for-land-restoration-scenarios-for-the-global-land-outlook-2

14 UN General Assembly, 2020. Implementation of the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa. A/RES/75/218. https://digitallibrary.un.org/record/3896583?ln=en

15 Atwoli, L., Baqui, A.H., Benfield, T., Bosurgi, R., Godlee, F., Hancocks, S., Horton, R., Laybourn-Langton, L., Monteiro, C.A., Norman, I. and Patrick, K., 2021. Call for emergency action to limit global temperature increases, restore biodiversity, and protect health: Wealthy nations must do much more, much faster. Nutrition Reviews, 79(11), pp.1183-1185. https://doi.org/10.1093/nutrit/nuab067

© usgs-unsplash

INTRODUCTION

Healthy and productive land resources – soil, water, and biodiversity – are the foundation of societies and economies. Roughly USD 44 trillion of economic output (more than half of global GDP) is moderately or highly reliant on natural capital.[1] However, in recent decades, land resources have been subject to persistent degradation and loss due to global patterns of human domination.[2] Most countries and communities now recognize the urgent need to transform land governance and restore natural capital to create meaningful jobs, reduce emissions, and restore harmony with nature.[3] Whether in managed or natural ecosystems, these activities can only be sustained by targeted government policies and budget outlays, considerable shifts in consumer demand and corporate investment, and more inclusive and responsible governance – all of which must come together to support regenerative land and water management practices on the ground.[4]

Natural capital is the stock of natural assets from which humans derive a wide range of goods and services and that sustain all life on Earth, often called ecosystem services.[5] [6] [7]

Land degradation is the reduction or loss of biological and economic productivity of land and its constituents: soil, water, and biodiversity.[8]

Land restoration is the process of avoiding, reducing, and reversing land degradation to recover the biodiversity and ecosystem services that sustain all life on Earth. Land restoration refers to a regenerative process along a continuum of land and water management practices adapted to local conditions and societal choices – applied to conserve natural areas, sustainably manage production landscapes, such as agriculture and forestry, and recover past ecological integrity.[9]

Turning Crises into Opportunities

The world is facing a confluence of unprecedented crises: the fast-moving COVID-19 pandemic has merged with the ongoing and relentless global changes in climate, land, and biodiversity. Collectively, these are causing extraordinary levels of human suffering, social and economic instability, and environmental devastation. Yet, hope remains as the decade of restoration has begun. Now is the time to harness political will, innovation, and collective action for short-term recovery and long-term regeneration to ensure a more stable and resilient future. Conserving, sustainably managing, and restoring land resources – and rationalizing consumer demand and respecting planetary boundaries – is a global imperative: one that requires moving to a crisis footing, putting people front and center, and making the land the focus.

UN Decade on Ecosystem Restoration

The Decade (2021-2030) is being championed by the United Nations Environment Programme (UNEP) and Food and Agriculture Organization (FAO) of the United Nations, in close collaboration with the Rio Conventions and other partners. It is a rallying call for the protection and recovery of ecosystems around the world to improve livelihoods, stabilize climate change, and halt biodiversity loss.[10] It is a global scale response that is necessary to mitigate human-induced environmental crises and achieve many of the targets in the Sustainable Development Goals.[11]

Land Degradation

Land degradation affects all types of land, from cities and rangelands to farmland and wilderness. While often quite evident on the surface, it is the hidden and insidious deterioration in the physical, chemical, and biological properties of soil, water, and biodiversity that is undermining human health and economic prosperity. Land becomes degraded in many ways. Some are natural or indirect, but most result from direct human activities. For example:

- People cut down **forests** for timber and fuelwood or to grow crops and graze livestock
- They convert **grasslands** or drain **wetlands** to cultivate food or expand urban areas
- **Mining** and **infrastructure** contribute to land degradation in both **urban** and **rural** areas
- In the **drylands**, the over-exploitation of soil, water, and vegetation results in **desertification**

The individuals and communities living and working on degraded land are most affected. Many are trapped in a downward spiral of land degradation and poverty, fueled by reductions in agricultural productivity and increased water scarcity. Land degradation gives rise to food insecurity and makes communities more vulnerable to disasters and increasingly intense and extreme weather events, like drought, floods, and wildfires. Poor rural communities, women, youth, indigenous peoples, and other at-risk groups are often the most exposed to these risks.

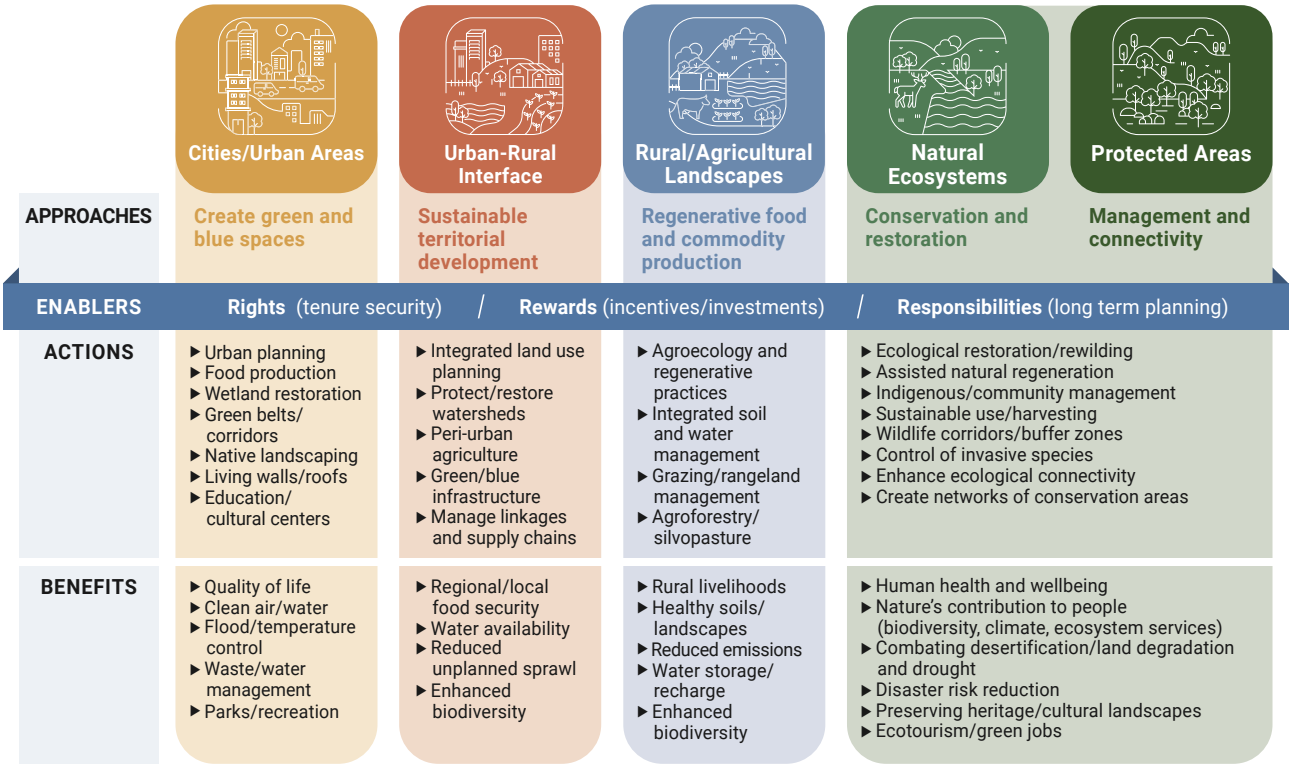
Most assessments show that between 20-40% of the global land area is degraded or degrading to varying extents and degrees.[12] [13] [14] The current model of natural resource extraction and economic growth has come at a great cost to human and planetary health. Nature conservation is no longer enough – restoration is now an imperative since it is the abundance and complexity found in healthy ecosystems that have made complex human societies possible. A true cost-benefit accounting of environmental degradation makes clear that more sustainable and regenerative approaches to land and water management are technologically feasible and profitable.[15]

Land Restoration

Land restoration is location specific: it can be active (such as planting grasses, shrubs, and trees, or managing soils and wildlife), or passive (such as allowing land to recover by itself after disturbance). The scale of restoration can range from a few hectares to thousands of square kilometers. In the field, integrated methods of crop, tree, and livestock production conserve water, replenish soils, reduce emissions, store carbon, and conserve biodiversity. In the wider landscape, key biodiversity and watershed areas can be protected and restored to improve water supply, disaster risk reduction, and the delivery of other ecosystem services. In cities and peri-urban areas, green and blue spaces (ecological infrastructure) can be expanded in the form of parks and woodlands, community gardens, buffer zones, and riparian corridors.

© Axel Fassio_CIFOR

FIGURE 1 Place-based restoration approaches, actions, and benefits



Land restoration is a multiple benefits strategy. It creates jobs, generates prosperity, and helps build community and ecosystem resilience to climate change and natural disasters. Benefits include reducing emissions and storing carbon, improving water quality and availability, and expanding natural habitat for wildlife and the provision of ecosystem services. Restoration can also foster landscape and biocultural renaissance through the revival, rediscovery, and application of traditional knowledge or customs that have been abandoned or neglected.

Land restoration alone is not enough. Despite all its potential benefits, restoration activities will have to be integrated into equally important measures to meet future energy needs while reducing greenhouse gas emissions. Land and soil restoration must also address growing food and water insecurity while shifting to more sustainable forms of production and consumption.[16] Sustainable land and water management is critical to accelerate the transition to a circular economy that significantly reduces pollution and waste.[17]

Land Degradation Neutrality

SDG Target 15.3 ('Life on Land') states that "by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought, and floods, and strive to achieve a land degradation-neutral world".[18] This target specifically calls on countries to strive to achieve Land Degradation Neutrality (LDN) by 2030; in other words, attain no net loss of land-based natural capital with net gain as the ambition. While focused on avoiding, reducing, and reversing land degradation in managed and natural ecosystems, LDN is fully compatible with the 'nature-positive' ambition expected to underpin the post-2020 global biodiversity framework.[19] [20]

LDN is defined by the UNCCD as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems".[21] As of 2021, more than 115 countries had made quantitative, area-based commitments to restore one billion hectares. Almost half of these are pledged as voluntary national LDN targets under the UNCCD, including 250 million hectares of farmland – an area equivalent to the size of Kazakhstan.[22]

The UN General Assembly has affirmed that combating desertification, land degradation, and drought – and achieving land degradation neutrality – is an effective pathway to accelerate progress towards achieving multiple Sustainable Development Goals.[23]

Land Governance

Land governance refers to people's relationship with the land. It concerns the rules, processes, and structures through which decisions are made about access to land, ownership, and use; the way these decisions are implemented and enforced; and how competing interests are managed.[24] Land governance is often seen as a legal and policy framework for land, involving a variety of formal and informal institutions and arrangements focused primarily on land tenure and land use planning.

Everyone has a role to play in restoring land – individuals, communities, businesses, governments, and international organizations all have a stake in the future. This implies a sense of shared responsibility to protect the global commons,[25] restore degraded land and soil,[26] and re-establish a 'safe operating space for humanity'.[27] Responsible land governance – affirming rights, offering rewards, and assuming responsibility – can incentivize more efficient, equitable, and sustainable ways to use and manage land resources.

Land restoration is about creating sustainable livelihood opportunities for people. Translating restoration commitments into action requires a significant realignment or repurposing of human, social, and financial capital to create the necessary enabling environment. This is supported by inclusive and well-aligned social, economic, and environmental policies, trusted institutions that facilitate partnerships and access to finance, and a robust knowledge base to inform land-based interventions.[28]

- **Secure tenure and resource rights** promote conservation, sustainable management, and restoration by empowering stakeholders to engage in planning, decision-making, implementation, and benefit-sharing processes.
- **Investment and incentives** motivate and enable individuals and communities to design, implement, scale, and sustain different types of land restoration activities.
- **Education and awareness** inform stakeholders of challenges and potential solutions while nurturing a sense of individual or collective responsibility to think, act, and plan long-term.

Global Land Outlook

In 2017, the UNCCD secretariat published the **first edition** of the Global Land Outlook, which underscored the wide-ranging drivers, risks, and impacts of persistent land degradation.[29] These have intensified considerably in the last five years, with the deterioration of human health, economic growth, and social equity becoming increasingly evident. This **second edition** aims to support and activate the vision of the UN Decade on Ecosystem Restoration with an evidence-based review of land-related challenges and solutions, and by offering inspirational examples of restorative pathways that can allow countries and communities to implement their bespoke land restoration agenda.

The vision for the UN Decade on Ecosystem Restoration is a world where the relationship between humans and nature is restored by increasing the extent of healthy ecosystems, and putting a stop to their loss, fragmentation, and degradation.[30]

Part One presents the multiple challenges to land systems, from the underlying biophysical drivers to the pressures created by socio-economic demands. Land governance issues feature prominently, given their importance for the uptake and sustainability of restoration activities.

Part Two features case examples and good practices that illustrate how different stakeholders can create new economic opportunities and meaningful livelihoods through land restoration. Examples include rewilding, regenerative agriculture, green infrastructure, and community-based solutions applied at different scales and in diverse biophysical and socio-economic contexts.

Part Three stresses the need for partnerships and cooperation, presents scenarios that quantify the potential of land restoration and protection, and showcases how national commitments can leverage a suite of land-based restoration pathways for recovery and resilience.

ENDNOTES

1 World Economic Forum, 2020. Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy. New Nature Economy series. WEF, Geneva. https://www.weforum.org/reports/nature-risk-rising-why-the-crisis-engulfing-nature-matters-for-business-and-the-economy

2 European Commission Joint Research Centre, 2018. World atlas of desertification: rethinking land degradation and sustainable land management. EC Publications Office, Brussels. https://data.europa.eu/doi/10.2760/9205

3 UN General Assembly, 2019. United Nations Decade on Ecosystem Restoration (2021–2030). Resolution 73/284. UN, New York. https://undocs.org/pdf?symbol=en/A/RES/73/284

4 Dasgupta, P., 2021, The Economics of Biodiversity: The Dasgupta Review. London: HM Treasury. https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

5 Blignaut, J., Aronson, J. and de Groot, R., 2014. Restoration of natural capital: A key strategy on the path to sustainability. Ecological engineering, 65, pp.54-61. https://doi.org/10.1016/j.ecoleng.2013.09.003

6 OECD, 2001. Glossary of statistical terms, Natural Capital. OECD publishing, Paris. https://stats.oecd.org/glossary/detail.asp?ID=1730

7 Millennium Ecosystem Assessment, 2005. Ecosystems and human well-being. https://www.millenniumassessment.org/en/index.html

8 UN Convention to Combat Desertification, 1994. Convention Text. UNCCD, Bonn. https://www.unccd.int/sites/default/files/relevant-links/2017-01/UNCCD_Convention_ENG_0.pdf

9 UN Environment Programme, 2021. Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate. UNEP, Nairobi. https://www.unep.org/resources/ecosystem-restoration-people-nature-climate

10 UN Decade on Ecosystem Restoration, (n.d.), Homepage. https://www.decadeonrestoration.org

11 IPCC, 2019. Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/srccl

12 Gibbs, H.K. and Salmon, J.M., 2015. Mapping the world's degraded lands. Applied geography, 57, pp.12-21. https://doi.org/10.1016/j.apgeog.2014.11.024

13 UN Convention to Combat Desertification, 2019. Preliminary analysis – strategic objective 1: To improve the condition of affected ecosystems, combat desertification/land degradation, promote sustainable land management and contribute to land degradation neutrality [ICCD/CRIC (17)/2]. UNCCD, Bonn. https://www.unccd.int/official-documentscric-17-georgetown-guyana-2019/iccdcric172

14 UN Economic and Social Council, 2019. Special Edition of the Sustainable Development Goals Progress Report: Report of the Secretary-General [E/2019/68]. UN, New York. https://unstats.un.org/sdgs/files/report/2019/secretary-general-sdg-report-2019--Statistical-Annex.pdf

15 The Economics of Land Degradation Initiative, (n.d.) Homepage. ELD, Bonn. https://www.eld-initiative.org

16 Anderson, C.M., DeFries, R.S., Litterman, R., Matson, P.A., Nepstad, D.C., Pacala, S., Schlesinger, W.H., Shaw, M.R., Smith, P., Weber, C. and Field, C.B., 2019. Natural climate solutions are not enough. Science, 363(6430), pp.933-934. https://doi.org/10.1126/science.aaw2741

17 European Parliament, 2021. Circular economy: definition, importance and benefits. News. European Parliament (03 March). https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

18 UN Department of Economic and Social Affairs, (n.d.) The 17 Goals. UN, New York. https://sdgs.un.org/goals

19 Convention on Biological Diversity, 2021. Post-2020 global biodiversity framework: scientific and technical information to support the review of the updated goals and targets, and related indicators and baselines scientific and technical information to support the review of the proposed goals and targets in the updated zero draft of the post-2020 global biodiversity framework [CBD/SBSTTA/24/3/Add.2/Rev.1], paragraph 12. https://www.cbd.int/doc/c/e823/b80c/8b0e8a08470a476865e9b203/sbstta-24-03-add2-rev1-en.pdf

20 Nature Positive, (n.d.) A Global Goal for Nature: Nature Positive by 2030. https://www.naturepositive.org

21 UN Convention to Combat Desertification, (n.d.) Land Degradation Neutrality. UNCCD, Bonn. https://www.unccd.int/land-and-life/land-degradation-neutrality/overview

22 Sewell A., van der Esch S. and Löwenhardt H., 2020. Goals and Commitments for the Restoration Decade: A global overview of countries' restoration commitments under the Rio Conventions and other pledges. The Hague, PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/goals-and-commitments-for-the-restoration-decade

23 UN General Assembly, 2020. Implementation of the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa: resolution adopted by the General Assembly [A/RES/75/218], UN, New York. https://digitallibrary.un.org/record/3896583?ln=en

24 FAO, 2022. Land governance and planning. FAO, Rome. http://www.fao.org/land-water/land/land-governance/en

25 Stafford-Smith, M. and Metternicht, G., 2021. Governing drylands as global environmental commons. Current Opinion in Environmental Sustainability, 48, pp.115-124. https://doi.org/10.1016/j.cosust.2020.12.006

26 UN General Assembly, 2015. Transforming our world: the 2030 Agenda for Sustainable Development | Resolution adopted by the General Assembly on 25 September 2015 [A/RES/70/1]. UN, New York. https://sdgs.un.org/2030agenda

27 Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J. and Nykvist, B., 2009. A safe operating space for humanity. Nature, 461(7263), pp.472-475. https://doi.org/10.1038/461472a

28 Verburg P.H., Metternicht G., Allen C., Debonne N., Akhtar-Schuster M., Inácio da Cunha M., Karim Z., Pilon A., Raja O., Sánchez Santivañez M., and Şenyaz A., 2019. Creating an Enabling Environment for Land Degradation Neutrality and its Potential Contribution to Enhancing Well-being, Livelihoods and the Environment. A Report of the Science-Policy Interface. UNCCD, Bonn. https://knowledge.unccd.int/publication/creating-enabling-environment-land-degradation-neutrality-and-its-potential

29 UN Convention to Combat Desertification, 2017. The Global Land Outlook, first edition. UNCCD, Bonn. https://www.unccd.int/resources/global-land-outlook/overview

30 UN Decade on Ecosystem Restoration, (n.d.) Homepage. https://www.decadeonrestoration.org

© markus-spiske-unsplash

PART ONE:
LAND IN FOCUS

Despite the environmental disasters that make the headlines every day, a renewed and sustainable relationship with nature is possible and within reach. Avoiding future calamities will require at least three global transformations enacted at speed and at scale, and where land is the focus: (i) a renewable energy infrastructure to reach net-zero emissions; (ii) a redesign of food systems that includes a wholesale shift to regenerative land and water management practices; and (iii) a rationalization of natural resource exploitation, land-based production, and consumption that respects planetary boundaries.[1]

Part One examines the current global land use system – its status, dynamics, and trajectories – and its consequences in terms of people, nature, and the climate. An in-depth assessment of the drivers and impacts of desertification and land degradation can be found in the *Global Land Outlook, first edition*.[2] **Section One** *(Earth in the Balance)* describes the growing imbalance between the human demand for land-based goods and services and nature's supply, with a focus on food and climate systems. **Section Two** *(People Front and Center)* outlines the critical role of inclusive and responsible land governance, advocating for rights-based approaches to adopt and scale up sustainable land and water management practices. **Section Three** *(Place-based Restoration)* showcases the land degradation challenges and regenerative solutions in specific land use contexts – the places where people live and work. **Section Four** *(Recovery and Resilience)* introduces the untapped potential of land restoration for an inclusive green recovery, improved human health outcomes, and disaster risk reduction.

> "Without large-scale and concerted efforts to protect, sustainably manage, and restore our land resources, it will not be possible to ensure food and water security, achieve climate targets, and halt biodiversity loss."
>
> UNCCD Executive Secretary Ibrahim Thiaw

1.1 EARTH IN THE BALANCE

If current land degradation trends continue during this century, scientists are predicting more severe climate-induced disturbances, resulting in food supply disruptions, forced migrations, and increased species extinction.[3] Humans have already transformed more than 70% of the Earth's land area from its natural state, causing unparalleled environmental degradation and contributing significantly to global warming.[4] [5] Business as usual raises the very real prospect of declining human health and economic prosperity, more zoonotic disease transmission, and greater conflict over land resources.[6]

Land degradation – the persistent decline or loss of soil, water, and biodiversity – has significant costs to society. This gives rise to poverty, hunger, inequality, and pollution, making communities more vulnerable to disease and disasters, like drought, floods, or wildfires. Desertification, land degradation, and drought already affect more than three billion people,mostly poor rural communities, small-scale farmers, women, youth, indigenous peoples, and other at-risk groups.[7] The situation is particularly acute in the dryland regions that cover over 45% of the total land area and are home to one in three people in the world today.

In 2019, an analysis of national reports submitted to the UNCCD conservatively estimated that on average 20% of global land is degraded to some extent – almost 30 million square kilometers, an area the size of the African continent.[8] Based on trends in indicators from 2000 to 2015:[9]

- land cover changes suggested a net loss in natural and semi-natural areas
- desertification, cropland expansion, and urbanization accounted for significant losses in soil organic carbon stocks
- there were persistent declines in productivity across all ecosystems, with grasslands incurring some of the largest losses

Governments and societies cannot afford to underestimate the scale and impact of present crises and future challenges. There must be urgent and collective action to meaningfully slow or reverse land degradation, climate change, and biodiversity loss while safeguarding human health and livelihoods, food, and water security.[10] Given the current understanding of causality and feedback loops, the human-environment relationship must drastically change to avoid catastrophic tipping points whereby the human power of exploitation is overwhelmed by the power of nature.

"Taken together, human actions are undermining and challenging the fundamental processes that underpin a habitable biosphere and Earth system resilience. It can no longer be taken for granted that the planet will be able to continue to support human wellbeing and development."[11]

International Science Council

Halting Biodiversity Loss

Biodiversity underpins the delivery of ecosystem services that sustain all life on Earth. Globally, the survival of many species is threatened by human encroachment, over-exploitation, and climate change. Global warming has altered geographic distributions, seasonal dynamics, and the population characteristics of many plants and animals.[12] Keystone species that have or will become extinct increase the risk of trophic cascades in food webs, ecosystem transformation or collapse, and the permanent loss of essential goods and services.

The Living Planet Index points to an average decrease of 68% in populations of mammals, birds, amphibians, reptiles, and fish between 1970 and 2016. For example, in the tropical Americas, the index declined by 94% primarily due to land use change, largely the conversion of grasslands, savannas, forests, and wetlands for agriculture and extractive industries. Between 2000 and 2018, the Species Habitat Index fell globally by 2%, with some regions suffering losses in the double digits.[13]

Rationalizing Demand and Respecting Boundaries

The direct drivers of land degradation include unsustainable land and water management practices in agriculture, forestry, urbanization, mining, and infrastructure development. These economic activities do not operate in a vacuum but are subject to external pressures, such as government policies, regulations, markets, and trade. These in turn are influenced by consumer demand and a wide range of social and demographic factors.[14] Collectively, these drivers and pressures increase competition for ever scarcer land and water resources, further widening the gap between human demand and nature's supply.[15]

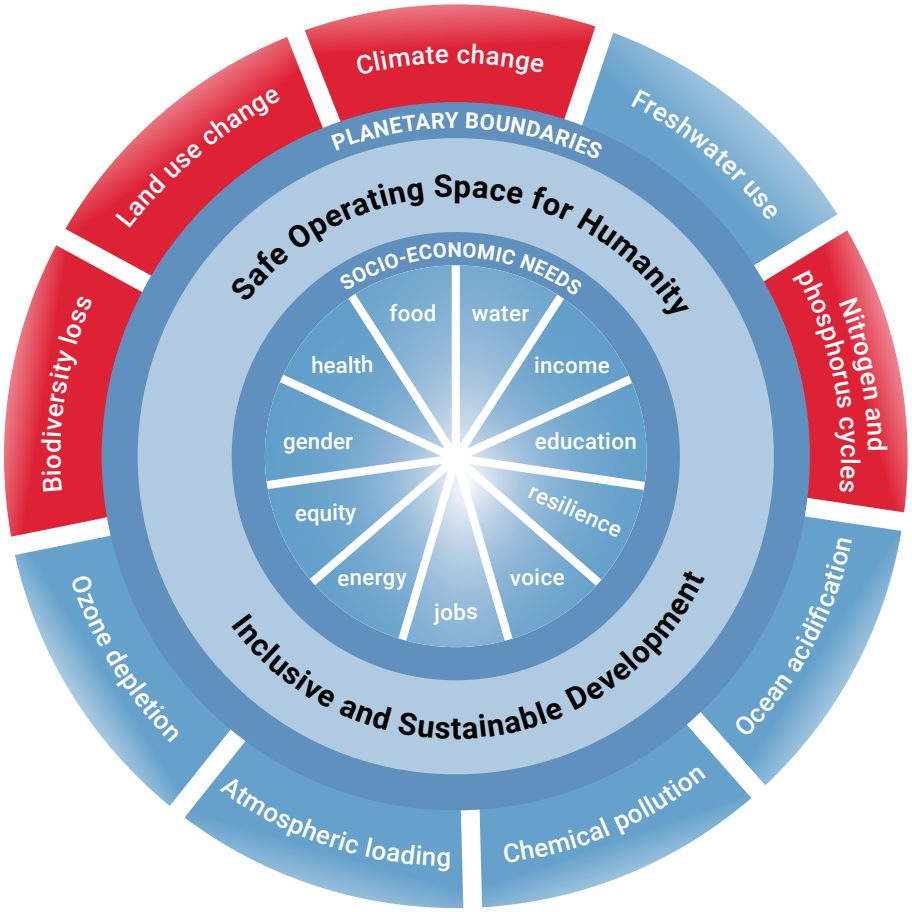
Land resources – soil, water, and biodiversity – are the stocks of natural capital that supply humanity with essential goods and services: food, fiber, raw materials, and a place to live and work. Many intangible or non-market ecosystem services have long been taken for granted. In recent times, land systems are increasingly being called upon to meet the demand for these services, such as pest and disease regulation, carbon sequestration, water purification, biodiversity conservation, waste recycling, and other services.[16] Recognizing and making decisions based on the full value of nature's contribution to people will guide land-based economic activities towards alternative modes of production that are both restorative and rewarding.

The Earth's bio-geochemical processes operate within boundaries that, if crossed, can lead to serious consequences for human health, economic prosperity, and planetary stability. Of nine planetary boundaries, the four which have been exceeded (i.e., climate change, biodiversity loss, land use change, and geochemical cycles) can be linked directly to the health of soil, water, and biodiversity. If current land degradation trends persist, the risk of widespread, abrupt, or irreversible environmental changes will grow.[17]

Framing the Land Restoration Agenda

While land can degrade rapidly, restoring it is generally a long-term endeavor that requires sustained effort and funding. Many terrestrial ecosystems retain their intrinsic capacity for renewal, particularly if the drivers and pressures of degradation are reduced or eliminated, while some are quickly approaching tipping points from which they will not be able to recover. Restoring degraded land and soil presents governments, businesses, and communities with multiple pathways to design and implement their unique land restoration

FIGURE 1.1 Nine planetary boundaries



Defining Land Restoration

In this Global Land Outlook and the UN Decade on Ecosystem Restoration, land restoration is broadly defined by a continuum of activities that avoid, reduce, and reverse land degradation with the explicit objective of meeting human needs and improving biosphere stewardship.[18] The priority is to avoid degradation by eliminating the drivers and expanding conservation and protected areas; reduce degradation through the adoption of sustainable land and water management practices in production landscapes; and reverse degradation through the passive or active restoration of biodiversity and ecosystem functions. Restoration activities, tailored to local conditions and societal choices, aim to regenerate natural capital for the benefit of human health and livelihoods, environmental and planetary resilience as well as to promote greater equity, social justice, and shared prosperity.

agenda. However, these actions will be futile if investment and incentives continue to encourage the over-exploitation and abuse of land resources.

The COVID-19 pandemic has fundamentally altered the way decision-makers, businesses, and civil society view the links between human and environmental health. The One Health approach calls for multi-sector collaboration that restores diversity and resilience in landscapes to safeguard the health of communities and ecosystems.[19] This involves effectively managing, expanding, and connecting protected areas; improving soil, crop, and livestock health; creating green and blue spaces in and around cities; and rewilding natural ecosystems. Collectively, these restorative actions will reduce the risk of zoonotic disease transmission, increase food and water security, and improve human health and livelihoods.

Fully activating the land restoration agenda will be essential to help recover from present crises and build a more prosperous and sustainable future. Investing in restoration makes sound economic sense and the benefits generally far exceed the costs: for example, each dollar invested in restoration activities is estimated to return between USD 7-30 in economic benefits.[20] Globally, the cost of land restoration is estimated to be at least USD 300 billion annually to achieve significant results by 2030,[21] [22] far less than the amount of subsidies currently provided to farmers in developed countries.[23] Investments in restoration will create meaningful jobs, providing secure livelihoods at a time when hundreds of millions of jobs have been lost. Sustained finance will require planning and partnerships that have the capacity to bundle different forms of capital and manage trade-offs to generate equitable restoration outcomes.

Governments, businesses, and communities can restore together by seeking convergence and complementarity. To be successful, the land restoration agenda will require targeted government policies and budget outlays, considerable shifts in consumer behavior and corporate investment, and more inclusive and responsible land governance. The assumption is that environmental and development priorities can be co-managed to create a healthier and more sustainable mosaic of land uses. New narratives and mindsets will foster collaboration, new tools and skillsets, and attract finance to pursue multiple benefit solutions.[24] All of the above are the enabling conditions needed to **motivate**, **enable**, and **implement** biodiverse, regenerative, climate-smart, and integrated land and water management practices.

- **Awareness is the precursor of change and motivates restorative actions** – based on an understanding of land degradation impacts and which draws inspiration from practical solutions, many of which can be found in Part Two of this Outlook.
- **Building and aligning human, social, and financial capital enables restoration efforts** – by creating inclusive opportunities and empowering communities and societies with a sense of ownership, trust, and unity.
- **Implementation takes place locally, on the ground, ideally by communities with a shared vision** – whereby both individual and collective action can help drive economic growth, environmental stewardship, and biocultural renaissance.

Land restoration is a shared responsibility – whether by reducing consumer footprints or actively regenerating natural capital – everyone has a role to play because everyone has a stake in the future.

1.1.1 TRANSFORMING FOOD SYSTEMS

Modern agriculture has altered the face of the planet more than any other human activity – from the production of food, animal feed, and other commodities to the markets and supply chains that connect producers to consumers. Large-scale intensive monocultures, industrial livestock operations, and the destruction of forests and other ecosystems generate the bulk of greenhouse gas emissions associated with food and commodity production.[25] [26] Concerted efforts to transform food systems and make them more sustainable and resilient would represent a significant contribution to the success of the global land, biodiversity, and climate agendas.

> "Food systems are one of the main reasons we are failing to stay within our planet's ecological boundaries." [27]
>
> UN Secretary-General António Guterres

Food systems must continue to provide sustenance but can be redesigned and redeployed to ensure positive outcomes for nature and climate as well. A transition to plant-based diets, where appropriate, would be a logical first step as nearly 80% of total agricultural land is dedicated to feed and livestock production while providing less than 20% of the world's food calories.[28] Eliminating or repurposing harmful farm subsidies would trigger a shift from resource-depleting practices to those that link resource efficiency and productivity gains to healthy and resilient food systems, decoupling economic growth from land and soil degradation.[29]

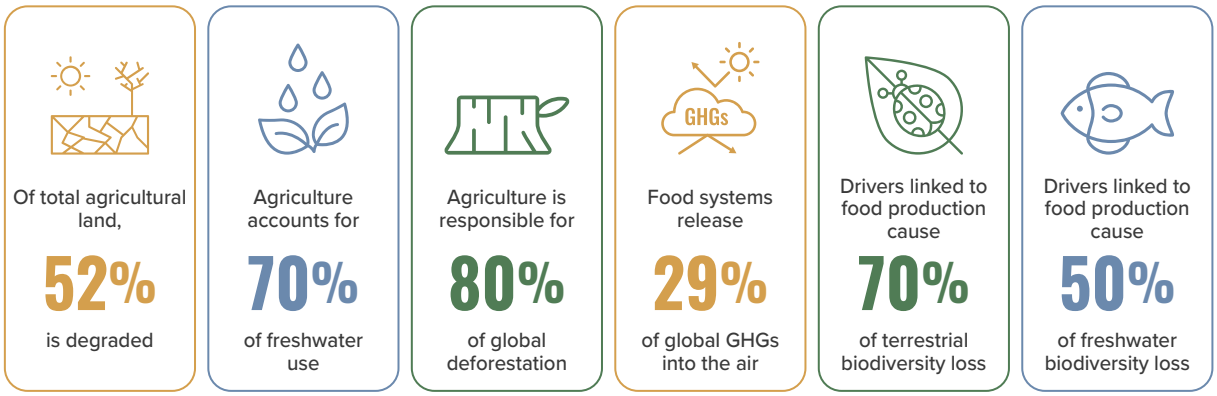
At the United Nations Food Systems Summit 2021, governments committed to accelerate and deepen food systems transformation to better align national policy and action with the 2030 Agenda for Sustainable Development.[31] Following the summit, agricultural ministers at the 2022 Global Forum for Food and Agriculture:[32]

- recognized that desertification, land degradation, and drought represent massive threats to global food security, nutrition, and sustainable food systems worldwide
- stressed that healthy soils are key to the production of sufficient nutritious and safe food, adaptation to and mitigation of climate change, and the halting and reversal of biodiversity loss
- emphasized that secure access to agricultural land through ownership, use rights, and other forms of legitimate tenure is of great importance for local and global food security

Many traditional and modern food production practices can enable agriculture to pivot from being the primary cause of degradation to becoming the principal catalyst for land and soil restoration. As with all innovation that disrupts established systems, this transformation will require time and money. Sustainable food production alternatives, inspired by agroecological approaches, are affordable and effective.[33] The transition to regenerative agriculture practices will entail variable timescales, approaches, and incentives depending on the scale and resource use intensity of food producers.[34] [35]

As agriculture now occupies approximately 40% of the global land area, restoring health and productivity to food landscapes will be essential for survival and sustainability.[30]

FIGURE 1.2 Current impacts of food production on nature



Producing More with Less

Food systems are complex and involve diverse stakeholders with different needs and aspirations. These include governments and multinational corporations, processors, traders, retailers, large- and small-scale farmers, indigenous peoples and local communities, women, and youth. Agriculture alone employs more than one-quarter of the world's workers.[36] Yet, over 80% of all farms are smallholdings of under two hectares, covering only 12% of total farmland.[37] More than 70% of the world's agricultural land is controlled by just 1% of farms, primarily large agribusiness concerns.[38]

Agroecological approaches and regenerative practices stimulate greater resource use efficiency, helping to protect and restore biodiversity and ecosystem services.[39] These practices can lead to higher total farm yields and better nutritional values when compared to resource-intensive monocultures.[40] When supported by the right policies and regulations, improved soil health will increase not only land productivity and biodiversity, but also the total amount of carbon sequestered.[41]

Agroecology is the application of ecological concepts and principles to the design and management of sustainable agroecosystems, sometimes referred to as the science of sustainable agriculture.[42]

Regenerative agriculture encompasses techniques that restore soil health and protect water and biodiversity by controlling soil erosion, reducing tillage, and the use of agrochemicals, and adopting integrated systems of crops, trees, and livestock, in addition to a wide array of other farm restoration measures.[43]

Family farms produce 80% of the world's food in value terms.[44] These lands are key sources of the diverse diets that provide food and nutrition security for local communities. Agroecological and regenerative methods are particularly well-suited to small-scale food producers, who typically rely on low-tech and labor-intensive practices. Reduced dependency on external inputs (e.g., agrochemicals, heavy machinery) saves money and reduces harmful environmental impacts, such as groundwater pollution, soil compaction, or erosion. In many cases, the uptake of regenerative practices is dependent on farmers funding the startup costs associated with revitalizing soil health.

Supporting and investing in smallholders is a pro-poor approach to scaling up nature-positive food production. Almost 30% of small farms have already shifted to more sustainable practices, accounting for 9% of global agricultural land.[45] Aligning small-scale production to local and regional demand for diverse, nutritious foods can reduce the pressure to expand farming into natural ecosystems while simultaneously revitalizing the urban-rural linkages necessary for a healthy regional economy. Secure land tenure and access to technology, credit, and markets all support the role of smallholders as agents of change and encourage the uptake of agroecological innovations.

© Muhammad Sidik_CIFOR

Drought and Water Scarcity

All countries are exposed to drought and water scarcity. Droughts are periods of abnormally dry weather when a lack of precipitation causes serious hydrological imbalances. The longer-term issue of water scarcity occurs when freshwater supply falls short of demand for human and environmental uses. Over one-third of the world's population currently lives in water-scarce regions.[46] Rising temperatures and higher variability in rainfall are increasing the frequency, extent, duration, and intensity of droughts and expanding areas experiencing water scarcity.

While agriculture is the single largest user of freshwater globally, it also offers great potential to improve water quality and availability where it is needed most. Healthy soils, crop and grazing lands have a natural capacity to store and filter water, but this capacity is diminished when they are degraded. Similarly, land use changes, such as the conversion of wetlands and forests, disrupt the water cycle and hydrological functions. Poor irrigation management and drainage can lead to lower quality soils. To combat drought and achieve long-term water security, it is necessary to protect and sustainably manage soil and water resources in food production landscapes.

Food Security, Trade, and Governance

Global trade and investment in food systems can play an important role in delivering more sustainable outcomes for people, nature, and climate. International trade and agribusiness contracts could be designed to help avoid further land conversion and environmental degradation as well as reverse growing socio-economic inequalities in food exporting, developing countries.[47] [48] While global trade lowers commodity prices, it also increases reliance on foreign land resources to meet national demand, leading to land use change and the displacement of other land uses in food-producing countries.[49] For example, wealthy countries – responsible for 44% of food waste and loss globally – import cheap food, which in turn increases soil degradation, biodiversity loss, and water scarcity in countries where the food is grown.[50] In contrast, poorer countries with growing populations and often exporters of land-based commodities (e.g., cocoa, coffee, cotton) are likely to be increasingly dependent on imports of cheaper and lower quality food from developed countries to feed their populations.[51] [52]

Consumers drive what and how much food is produced and even help determine sourcing and production methods. Increased consumer awareness can have nature-positive impacts beyond local scales. For example, more sustainable dietary choices can help protect pollinating insects in their own country or prevent a distant rainforest from being cut down. Businesses can form alliances to embrace sustainability standards and label products to disclose the full environmental and climate footprint of their production and distribution. Parents and schools can teach the next generation about the importance of healthy land and soil to human nutrition and wellbeing. Informed public opinion can pressure governments to pass laws and enforce regulations to drive the transformation of food systems.

In some countries, food security could be improved by limiting and regulating the amount of land owned or leased by transnational corporations for food and commodity production and exports.[53] For example, governments can re-evaluate large-scale landholdings and prioritize land resources for local food producers and domestic consumption by changing their regulatory or fiscal frameworks. Without such measures, poverty, hunger, forced migration, resource conflict, and inequality will likely continue to increase as will large-scale land acquisitions ('land grabs'). Food security should be seen as a human right that deserves to be treated as such in national food systems and international agribusiness deals.[54]

Farmers and other actors in the food system often respond to market signals and government policies. For example, a combination of market distortions (e.g., price supports, inefficient supply chains) and government policies (e.g., subsidies, regulation) forces many farmers into a mode of production that relies on expensive inputs of genetically modified seeds, agrochemicals, irrigation, or machinery. These incentives are considered perverse because of their unintended and harmful effects on people and the environment. Repurposing these incentives can help eliminate or substantially reduce the startup costs associated with switching to regenerative practices, especially for the more than 600 million farming families across the globe.[55]

Over USD 700 billion is paid in agricultural subsidies each year, but only around 15% of this amount positively impacts natural capital, biodiversity, long-term job stability, and livelihoods.[56]

1.1.2 BOOSTING CLIMATE ACTION

The amount of greenhouse gases in the atmosphere – primarily carbon dioxide, methane, and nitrous oxide from land systems – depends on fluxes in source emissions and their duration as well as their removal and storage via sinks.[57] The 2015 Paris Agreement set an ambitious goal of achieving net-zero emissions by 2050 to limit global warming to well below 2°C, and preferably to 1.5°C, compared to pre-industrial levels.[58]

Protecting and restoring land resources reduces emissions and sequesters carbon, providing more than one-third of the cost-effective, land-based climate mitigation needed between now and 2030 to stabilize warming.[59] In addition to its mitigation potential, land-based climate solutions enhance adaptation through:

- effective management and expansion of networks of conserved and protected areas.
- sustainable land and water management practices in working rural landscapes.
- ecological restoration or rewilding of biodiversity and well-functioning ecosystems.[60]

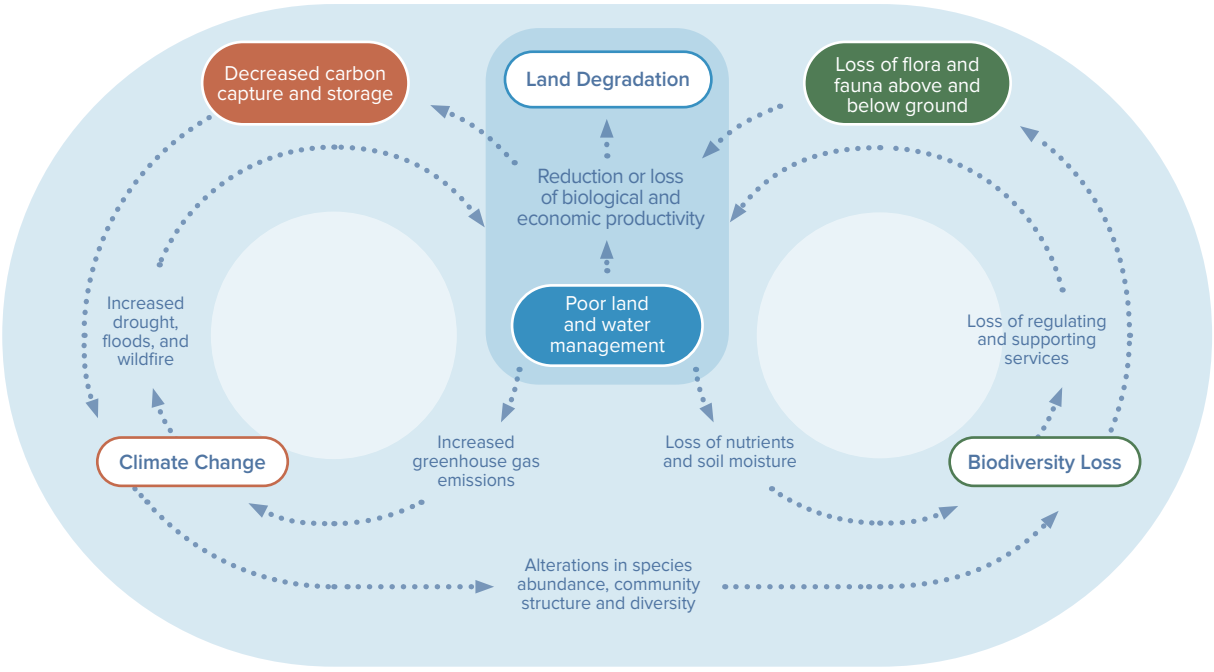
Land Degradation Contributes to Climate Change

Land health and productivity, determined by land use and management practices, impact global, regional, and local climate conditions. Changes in land cover (e.g., deforestation, urbanization), land use (e.g., livestock, irrigation), and land condition (e.g., water retention, biomass productivity) affect local temperature and weather patterns in addition to being a significant source of greenhouse gases that contribute to regional and global warming, primarily because of reduced vegetation cover.[61]

- Nitrous oxides from fertilizer use and methane from ruminant livestock form the largest and most potent share of agricultural emissions.[62]
- Deforestation and the draining and burning of peatlands for food and commodity production generate the bulk of carbon emissions associated with land use change.[63]
- Intensive tillage and subsequent soil erosion over centuries have released large amounts of carbon dioxide into the atmosphere.[64]

While terrestrial and oceanic sinks have removed over half of the carbon emissions generated from human activities, the rate of sequestration is now declining. If land degradation continues unabated, this could potentially trigger a reversal from land being a net sink to being a net source.[65]

FIGURE 1.3 Feedback loops between land degradation, climate change, and biodiversity loss



Source: Millennium Ecosystem Assessment, 2005.

Climate Change Worsens Land Degradation

Climate change can accelerate or intensify land degradation, increasing current risks to human health and livelihoods, food and water availability, biodiversity, and ecosystem functions.[66] Hotter temperatures, along with longer, more intense droughts, wildfires, and extreme rainfall events, weaken ecological integrity and resilience in both managed and natural land systems. Many forests and grasslands around the world are now more susceptible to pest and disease outbreaks; land use change leads to greater disease transmission from animals to humans.[67] Higher average temperatures and changes in rainfall patterns have already reduced crop yields and soil moisture.[68] This, in turn, increases demand for groundwater extraction and irrigation, which can result in desertification in the dryland regions.[69]

Global warming threatens the health of peatlands and permafrost, which store huge amounts of greenhouse gases and provide essential services and unique habitats for many species. While only 3% of the global land surface, peatlands are drying out as result of climate change. Melting boreal permafrost could release massive volumes of carbon dioxide and methane. Such land degradation, in the form of soil erosion, flooding, and landslides, creates negative feedback loops that could surpass climate thresholds and accelerate global warming far beyond human control.[70]

The lethal combination of climate change and land degradation could force millions of people to migrate to cities and across continents in search of more secure livelihoods.

Boosting Soil Health

Soils are the most complex and biodiverse ecosystem in the world. Their water and carbon storage are essential for soil fertility, releasing nutrients for plant growth, and supporting the structural and biological health of the soil. Unsustainable management practices in the name of global food security are placing extraordinary pressure on soils.[71] After oceans, soils are the second largest carbon sink, so targeted policies and incentives to scale up sustainable use will be necessary to maintain this potential.[72]

Soils and below ground biodiversity are the source of most food calories consumed globally.[73] They also help regulate atmospheric greenhouse gases, recycle waste, and can mitigate drought and flood risks. Throughout history, farming has released roughly 116 billion tonnes of carbon into the atmosphere, with the rate of loss increasing dramatically in the last 200 years.[74] Soil organic carbon represents 25% of the full potential of natural climate solutions, equally divided between protecting existing carbon stocks and restoring depleted ones. Improving soil health comprises 9% of the mitigation potential of forests, 72% of wetlands, and 47% of agriculture and grasslands.[75]

© ricardo-mayer-shutterstock

Fertile Ground for Climate Action

There is no viable solution to the climate crisis without transforming land use, management, and governance. Land restoration offers numerous pathways to reduce emissions, sequester carbon, and enhance human and environmental resilience to cope with the expected impacts of climate change.

- **Reducing emissions.** In Latin America, sub-Saharan Africa, and Southeast Asia – where emissions due to land use change are rising – the biggest mitigation opportunities involve sustainable intensification practices that avoid deforestation and ecosystem conversion. In many emerging and developed economies, emissions can be significantly reduced by improving input use efficiencies, adopting sustainable soil and livestock management practices, shifting consumer demand towards plant-based diets, and reducing waste.[76]
- **Storing carbon.** Food and commodity production systems that utilize a diversity of crops, animals, and native biodiversity – with different spatial and seasonal arrangements – can mimic natural regenerative processes that increase carbon storage. Ecosystem restoration, such as the conversion of abandoned agricultural land back to grassland or forest, is one of the quickest ways of boosting natural capital and carbon stocks.[77]
- **Enhancing resilience.** Abundance and complexity in both managed and natural land systems reduce their vulnerability to risks associated with climate change and natural disasters. For example, farmers can draw on indigenous or traditional knowledge to adapt crop and livestock selection, better plan for sowing and grazing periods, or adjust management techniques to the changing climate. Pastoralists cope with climate and weather uncertainty by migrating to where pasture and water are available.

1.2 PEOPLE FRONT AND CENTER

The UN Decade on Ecosystem Restoration was launched in June 2021, seeking to reimagine, recharge, and restore natural capital in agricultural land, forests, wetlands, drylands, and grasslands. The theme is especially relevant in the context of restoration activities that seek improvements in social and ecological systems.[78] For many communities, land and ecosystem restoration is fundamental to their survival, cultural heritage, sense of place, and material wellbeing – in essence, restoration is environmental or biosphere stewardship that puts people front and center.[79]

Access to and control over land resources by individuals and communities is a fundamental part of inclusive land governance and sustainable land use practices.

Inclusive Land Governance

The history of land governance has shaped current land use and management practices. It is also reflected in the access to and control over land resources, markets, supply chains, and trade which has resulted in an unequal distribution of costs and benefits – with relatively few winners and society at large bearing most of the burden. The COVID-19 pandemic has exposed and exacerbated many of these inequalities in income, labor, health, and education.[80]

Rights are about inclusivity, entitlement, and the equity enjoyed by virtue of being human. Many individuals and communities do not enjoy even the most basic human rights, such as secure tenure or resource rights.

Rewards encourage people to protect, sustainably manage, and restore land resources. Options include regulations, subsidies, and market incentives that create green job opportunities and encourage nature-positive business models.

Responsibility to provide a healthy land legacy for future generations is held by all sectors of society. This will require a shift to long-term planning and decision-making based on an awareness of how current economic and governance structures influence land use and management.

Many stakeholders, from local to global, have a vested economic interest in protecting and restoring the land. To leverage this motivation, land governance will have to be participatory, defend human rights, and deliver greater equity to achieve transformation on the scale needed. This means addressing inequalities in stakeholder engagement, decision-making power, and benefit sharing. The challenge for responsible governance lies in managing trade-offs and optimizing synergies among a mosaic of land uses and land users.[81]

Land governance can be reformed or restructured in ways that promote the rights and dignity of all people. Land restoration measures will contribute to environmental sustainability. However, if not designed and implemented responsibly, they could risk disenfranchising the most vulnerable and threaten their health, homes, and livelihoods. For example:

- Large-scale restoration activities and the expansion of protected areas could negatively impact **indigenous peoples and local communities** that legitimately occupy or claim these lands through customary systems that rarely are legally documented.[82] [83]
- Land restoration initiatives could also negatively impact **small-scale farmers and pastoralists** who lack tenure security, especially **women and young food producers** who tend to have the most precarious rights and access to land resources.
- Urbanization and peri-urban settlements will continue to expand under any future scenario, in some cases because of exclusionary restoration activities that increase migration from rural areas or occur at the expense of fertile agricultural land or natural areas that provide essential services to the **poorest and most vulnerable**.[84]

1.2.1 RIGHTS-BASED APPROACHES

Land restoration is much more than just rehabilitating natural areas and preserving their functions. It is about creating livelihood opportunities for people in which they can participate and benefit in tangible ways. This is especially true for poor and disenfranchised communities who have limited or no access to land resources, yet are the most affected by environmental degradation and most exposed to disaster risks.

Rights-based approaches to land restoration involve inclusive governance, secure tenure, and environmental justice. These approaches focus on the obligations of duty bearers and what is owed to rights holders as well as the principles of participation, accountability, transparency, equality, and non-discrimination. These principles were recognized by the United Nations Conference on Environment and Development (1992 Earth Summit), which gave birth to the Rio Conventions and explicitly called for rights-based provisions "to facilitate the active involvement and participation of all concerned, particularly communities and people at the local level, in decision-making on land use and management".[85]

Small-scale Farmers

Land restoration measures can be designed and implemented to meet the needs of small-scale farmers. Almost 500 million smallholders control just 12% of the world's farmland, yet produce about one-third of the world's food,[86] with levels of production much greater in Asia and sub-Saharan Africa.[87] These farms provide livelihood opportunities for approximately two billion people,[88] conserving more biodiversity and yielding more food per hectare than larger farms.[89] However, the current trend is towards investments in large agribusiness concerns while governments scale back support to small-scale farmers. As a result, many smallholders remain in poverty and suffer from food insecurity as they are increasingly pushed onto marginal lands due to unjust land concentration.

Pastoralists

Pastoralists require security of tenure and certainty of access to land and water resources to engage in land restoration. Up to 500 million pastoralists herd their animals across rangelands, which are highly diverse, grass-dominated landscapes that cover one-third of the Earth's land surface.[90] [91] Traditionally, pastoralists have managed these ecosystems through customary arrangements that are now threatened by climate change and mobility restrictions,[92] as well as appropriation and encroachment.[93] [94] Their unique lifestyle – seasonal mobility, shifting boundaries, and the common use of grazing lands – presents challenges and opportunities for improving land use policy and governance in extensive food production systems.

Women

Gender-responsive land restoration ensures that women and men have an equal voice and influence in land use and management decisions and their outcomes. For example, evidence suggests a positive correlation between women's security of tenure and household expenditures on food and education.[95] Yet, due to cultural norms and societal values, they are often excluded from decision-making regarding the use and management of land and forests, thus restricting their access to extension services, markets, and credit. Gender-responsive training and capacity building for both women and men, along with the establishment of partnerships and networks, can help leverage women's unique knowledge, contributions, and priorities for land restoration.[96] [97]

FIGURE 1.4 Gender-responsive restoration

GENDER-RESPONSIVE LAND RESTORATION

ACTIONS	BENEFITS
Analyze gender roles in livelihoods activities and household tasks	Eliminate barriers that may impede women's participation in land restoration activities
Assess and document gender inequalities in land and resource rights (e.g., ownership, plot size, soil quality)	Empower women as landowners to take leadership roles that improve efficiency and effectiveness
Engage women and men equally in the design, implementation, and monitoring of land restoration initiatives	Improve access to credit and financial services and markets for value-added products
Provide women and men equal access to inputs and training, appropriate tools, technologies, and extension services	Encourage partnerships and networking associations
Avoid activities that will increase women's burden and unpaid work; undertake corrective measures as and when required	Enhance the ability to measure and demonstrate the contribution and impact of women's participation
	Ensure more equitable benefit sharing from restoration outcomes

The UN Declaration on the Rights of Indigenous Peoples and the principle of free, prior, and informed consent are the fundamental pillars of rights-based approaches to safeguard traditional ecological knowledge, ensure equitable benefit sharing, and promote ecosystem approaches that are essential for wide-scale conservation and restoration.[98]

© Kelley Lynch

Indigenous Peoples and Local Communities

Indigenous peoples and local communities are often the guardians of forests and other natural ecosystems. Indigenous peoples constitute over 6% of the world's population[99] and manage or have tenure rights over at least 38 million square kilometers in 87 countries on all inhabited continents. This represents more than 25% of the world's land surface, and intersects about 40% of all terrestrial protected areas and ecologically intact landscapes.[100] Their unique biocultural spaces and customary use help preserve agrobiodiversity, making food systems more resilient to climate change.[101] The continued and widespread disregard of customary, traditional, and indigenous land rights and, more recently, the growth in 'fortress conservation'[102] and large-scale land acquisitions[103] contributes to the further dispossession of indigenous peoples and local communities.

Youth

Regenerative agriculture, ecotourism, and protected area management represent a few of the opportunities to bring young people back to rural areas with the prospect of secure and stable livelihoods. Globally, over 1.2 billion people are aged under 25, 85% of whom live in developing countries.[104] Youth, particularly young women and girls, often face bias and discrimination around access to and control of land resources, due to land scarcity and cultural factors, such as inheritance systems.[105] Many developing countries have a stark policy choice to make – either create meaningful and dignified employment opportunities, especially in rural areas, and reap the demographic dividends of a young vibrant workforce – or face the social unrest and political instability that often accompany high rates of unemployment.[106]

Youth have an inherent right to be treated as partners in the governance of land resources as they are the ones who will inherit a legacy of degradation or restoration.

Displaced Peoples

By the end of 2020, it was estimated that over 82 million people worldwide had been forcibly displaced, including refugees and international migrants.[107] In 2020 alone, conflict and disasters triggered over 40 million new internal displacements, with more than half under the age of 18.[108] A host of new and volatile land challenges have arisen due to these large population dislocations. Competing claims to land by refugees, internally displaced people, and host communities are further complicated when existing tenure rights are largely undocumented.[109] The situation has been aggravated by the COVID-19 pandemic during which many local authorities have stopped receiving donor aid for land administration, resettlement, return migration, or job creation schemes.[110]

Social Equity and Environmental Justice

Environmental justice is fair treatment and inclusiveness for an equitable distribution of nature's benefits. The burdens of land degradation continue to fall disproportionally on the poor and disenfranchised, with their voices, experiences, and values often suppressed.[111] Justice requires inclusive decision-making that recognizes community identity and local knowledge,[112] ensures access to resources, markets, and services,[113] and promotes the responsible governance of land tenure.[114] Along with accountability and remedy mechanisms, these enabling factors can help ensure that restoration efforts do not ignore the rights and interests of individuals and communities currently using and managing the land.

The right to a healthy environment is protected by the constitutions of three-quarters of the world's nations.[115] In many cases, this specifies the equitable access to natural resources to meet the developmental and environmental needs of present and future generations.[116] Intergenerational equity is the idea that every generation holds the Earth in common with other generations. In meeting this obligation, addressing past and ongoing injustices will help create a robust and enduring dynamic for future equity and sustainability through improved land management, social cohesion, and more responsible governance.[117]

The Escazú Agreement

The Escazú Agreement is the first international treaty in Latin America and the Caribbean concerning the environment. It strengthens the links between human rights and environmental protection by imposing requirements upon states concerning the rights of environmental defenders. It aims to provide full public access to environmental information, decision-making, and legal protection and recourse concerning environmental matters. Most importantly, it recognizes the right of current and future generations to a healthy environment and sustainable development.[118]

1.2.2 LAND GOVERNANCE, TENURE, AND PLANNING

How land is governed affects its present and future health and productivity. The interrelated functions of governance, tenure, and land use planning are important enablers of land restoration. Land users are more likely to make investments when they have realistic expectations that they will benefit from the returns. Inclusive governance and tenure security are key elements that can be embedded in the design and implementation of land restoration activities. When integrated with land use planning, such governance can underpin the achievement of many of the Sustainable Development Goals – from reducing poverty, hunger, and water scarcity to creating decent jobs, empowering rural women, shifting to sustainable agriculture, and investing in conservation and restoration.[119] [120]

Land governance encompasses the rules, processes, and structures by which decisions are made about land access and use, the manner in which decisions are implemented and enforced, and the way that competing interests are managed.[121]

Land tenure concerns relationships among people with respect to land. Rules define access rights as well as responsibilities and restrictions related to the use, control, and transfer of land.[122]

Integrated land use planning is the systematic assessment of land and water potential, alternate land uses, and socio-economic priorities to select and adopt the best land use options to meet local, regional, or national needs while safeguarding land resources for future generations.[123]

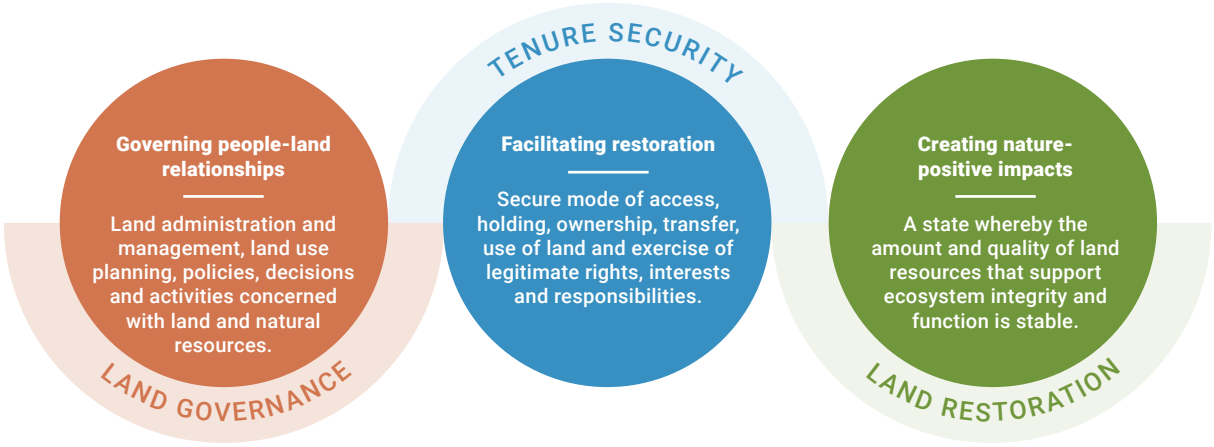
Many land restoration activities require flexible, decentralized governance to accommodate new knowledge and skillsets as well as the values, relationships, and engagement of multiple land users.

Land Governance

Social-ecological systems are more resilient, adaptive, and sustainable when multiple partners and local communities are involved. Responsible land governance facilitates land use policy choices and tenure rules that protect vulnerable groups and safeguard land resources. It guides the management of land rights concerning the ownership, possession, and use of land – and how it is valued and taxed. Land restoration typically involves diverse stakeholders and multiple layers of government interacting with the private sector, financing institutions, and local communities.

Multi-level governance arrangements can be effective in addressing local needs, matching them with available incentives and investments to facilitate participatory decision-making on restoration activities.[124] [125] In most cases, this entails sectoral coordination that prioritizes local communities by affording them rights to manage and restore land and forests. These initiatives can often be aligned with national agendas for climate action, biodiversity conservation, environmental justice, and sustainable development.[126]

FIGURE 1.5 Land governance, tenure security, and land restoration



Land Tenure

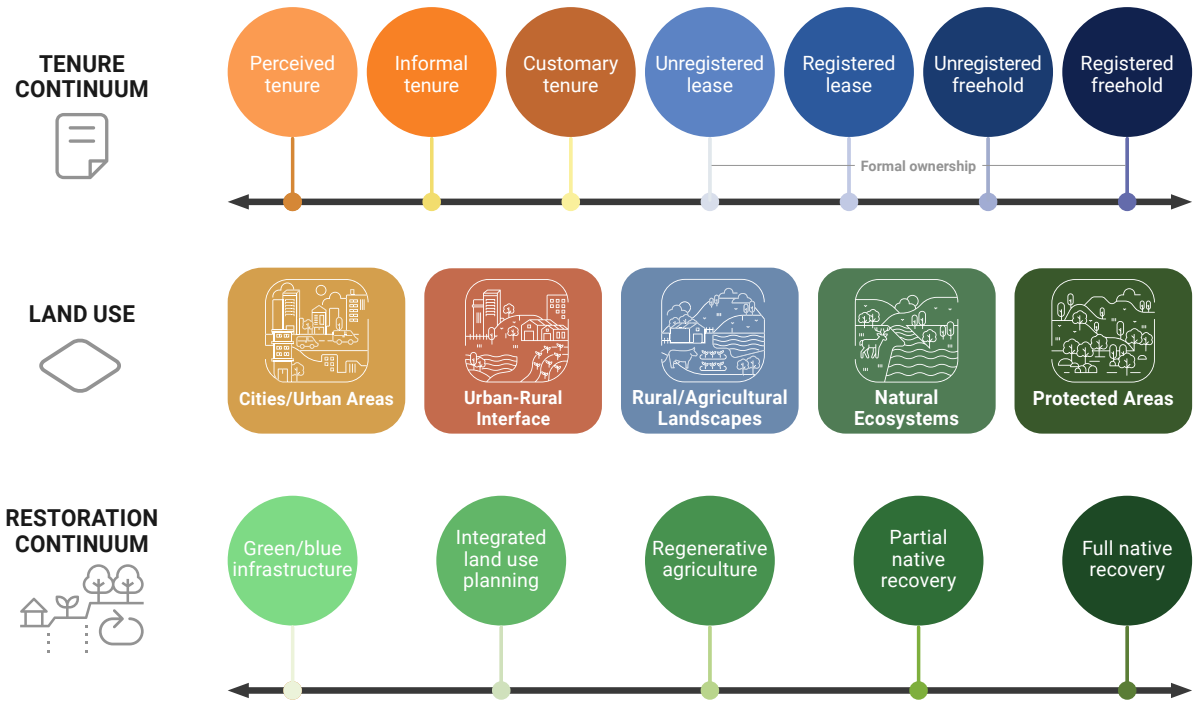
Who owns and controls land – how landholdings and leases are distributed across society – is central to the efficacy and sustainability of restoration activities.[127] While tenure tends to be associated with land, it also applies to its components, such as trees, water, or mineral resources.[128] It can also be seasonal, with different stakeholders holding different rights at different periods in the year, such as in the case of pastoralists or inland fisherfolk. The recognition and enforcement of legitimate land rights give users certainty and confidence, making them more likely to invest in and enjoy the benefits of restoration.

Land tenure and land restoration are interlinked – secure tenure, for example, can be an important enabling condition for land restoration.[129] The tenure-restoration nexus frames how land administrations create or enhance tenure rights, leading to formal recognition and documentation. Security of tenure can support and sustain land restoration activities through trusted institutions or governance structures, and the emergence of new rights and responsibilities attached to a landholding. There is a continuum of legitimate land and resource rights where full ownership is not the only, nor always the most effective, way to achieve secure tenure.[130] [131] [132]

Tenure security makes it possible to pivot from land degradation to restoration – it can be both a means and an objective of restoration activities.[133] It is the cornerstone of resilient agricultural systems and healthy rural communities: tenure arrangements, whether formal or informal, greatly influence land use and management practices. A pragmatic and gradualist approach offers an alternative to formal land titling – one that acknowledges indigenous or customary tenure systems and encourages compliance within their existing governance arrangements.[134] Where customary rights do not currently exist, a transfer of authority to community decision-making bodies can help establish locally appropriate and legitimate forms of tenure.[135]

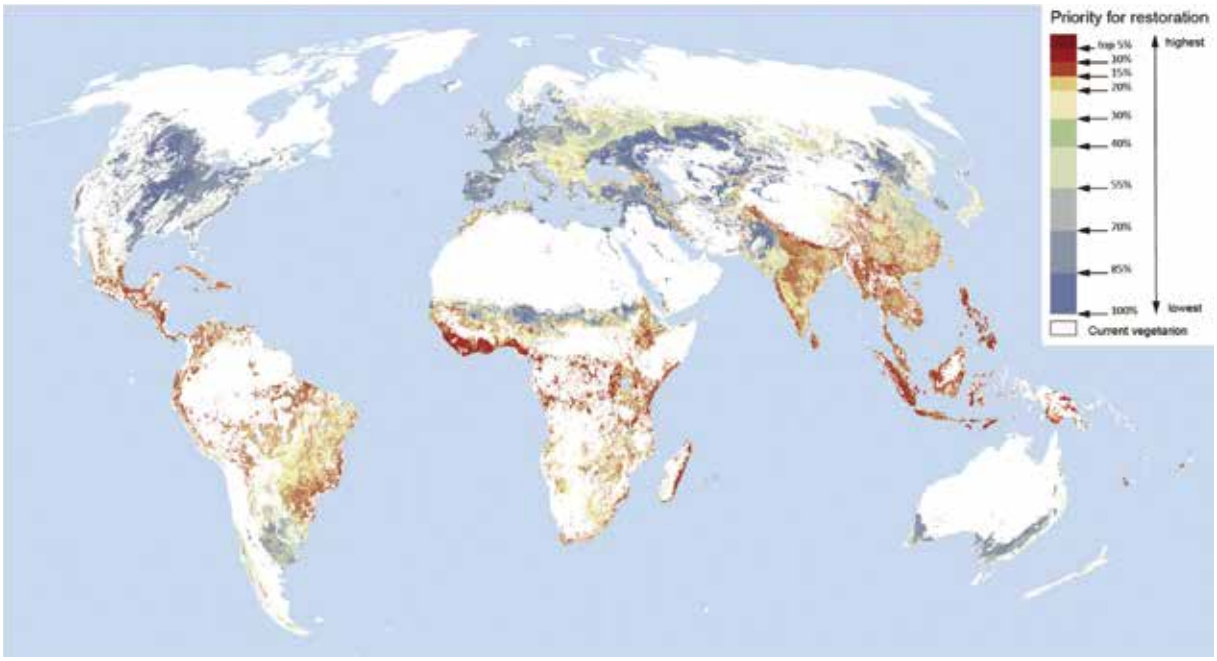
A rights-based approach to integrated land use planning treats individuals and communities as rights holders, and the state as a duty bearer committed to upholding human rights.[136]

FIGURE 1.6 The land tenure – restoration nexus



Source: Adapted from Chigbu et al. 2016 and Gann, et al. 2019

FIGURE 1.7 Global restoration hotspots (2020)



Source: Strassburg et al., 2020.

Integrated Land Use Planning

The primary objective of integrated land use planning is to allocate multiple land uses while accommodating diverse socio-economic preferences and ensuring sustainable use. However, many planning systems are implemented parcel by parcel within an administrative jurisdiction and do not consider the broader mosaic of land uses in the wider landscape.[137] Integrated land use planning can be a powerful tool to balance development and manage multiple land uses, such as commodity production, urbanization, and infrastructure development as well as recreation, tourism, and other ecosystem services.[138] [139]

Integrated land use planning can also be an effective means for securing tenure, providing an enabling framework for the recognition of legitimate forms of land and resource rights.[140] For the beneficiaries, this confers the legal and social freedom to make decisions on what, where, when, and how to use land resources to improve livelihoods and achieve food security objectives.[141] Land use planning instruments can be aligned with economic, fiscal, and other administrative tools, such as multifunctional land use zoning linked to land taxation, incentive schemes, or voluntary measures, such as conservation reserves.[142] [143]

National land use planning can align with global restoration goals to prioritize carbon-rich and biodiverse hotspots for the benefit of people, nature, and the climate.[144] Except for protected areas, these global public goods are only rarely explicitly linked to national planning, yet are essential for humans to cope with heat waves, drought, floods, wildfires, and other disasters.[145] Land use planning alone cannot prevent the disaster-related loss of nature and its functions; however, it can lessen the impacts when linked to conservation and restoration strategies.[146] For example, restoring tropical forests is important, not only locally and nationally, but also for the overall stability of the Earth's bio-geochemical cycles. The international community can do more to support countries, financially and otherwise, to uphold their special responsibility to protect these global public goods.

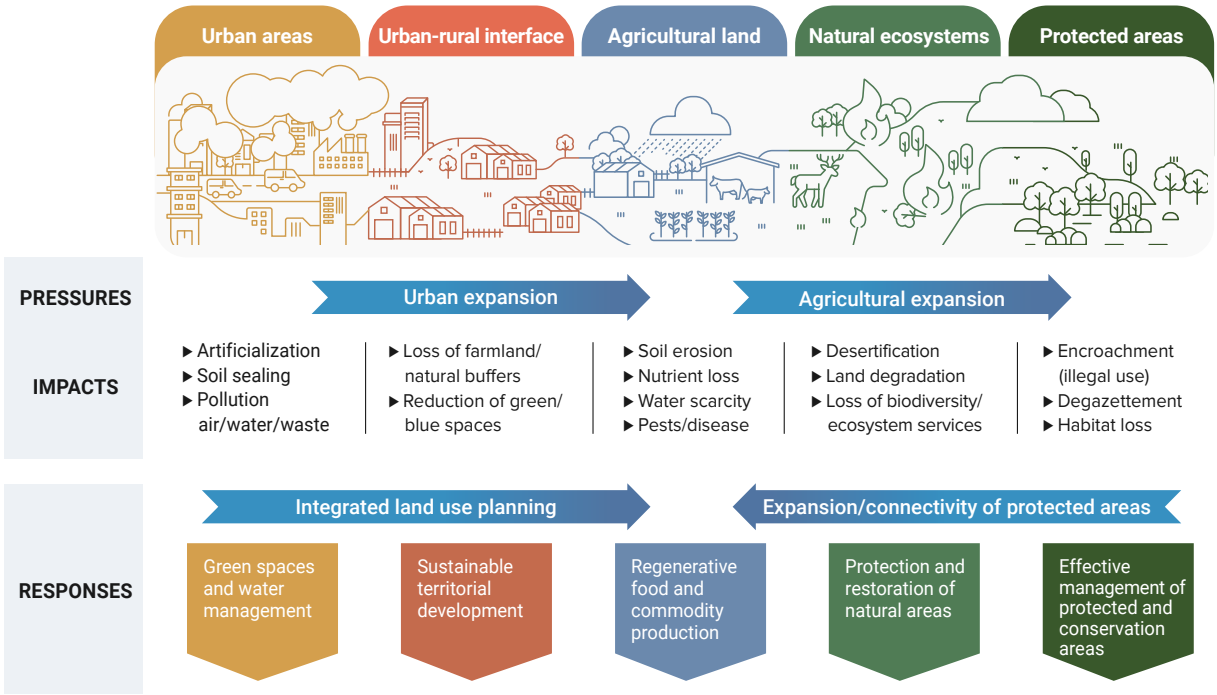
1.3 PLACE-BASED RESTORATION

Humans have created a vast network of land use types, each with distinct management practices. Land degradation occurs within all types amid a host of uniquely local characteristics and challenges. In urban, industrial, and mining areas, much of the vegetation and wildlife has been removed and replaced with asphalt, concrete, or bare ground. In many rural areas, complex biodiverse ecosystems have been supplanted by land-based commodity production systems dominated by just a handful of species. It is only in the relatively intact natural or protected areas that native flora and fauna still survive in habitats that can be considered historically representative.

Restoring the land is about creating livelihood opportunities for people, empowering them to adjust their relationship with nature and take the initiative where they live and work. Urban residents can mobilize neighborhoods and convince municipal governments to provide more green and blue spaces in their communities. Businesses and farmers can shift to nature-positive models and regenerative management practices that are sustainable and remain profitable. Indigenous peoples and local communities can be entrusted to care for natural and protected areas. Regardless of the place, land restoration is most effective when aligned with local development priorities and embedded within established social, institutional, and cultural contexts.

Everyone has a role to play in restoring land because everyone has a stake in the future.

FIGURE 1.8 Place-based restoration: Pressures, impacts, and responses



- **Cities and urban areas.** The environment and the quality of life for residents can be improved by planting trees, creating parks and community gardens, restoring wetlands, and daylighting rivers and streams.

- **Urban-rural interface.** Territorial planning can help growing cities to protect fertile land, limit waste and pollution, and develop green/blue spaces and infrastructure to strengthen urban-rural linkages.

- **Rural and agricultural lands.** Agroecological approaches and regenerative practices can enhance food and water security, reduce soil erosion, and greenhouse gas emissions while aiding in the recovery of biodiversity and ecosystem functions that have been lost.

- **Natural ecosystems.** Preventing further encroachment on and loss of natural and semi-natural areas would protect many of the ecosystem services that are vital to surrounding production lands and more distant population centers.

- **Protected areas.** Safeguarding, connecting, and effectively managing protected and other conservation areas would ensure the provision of global public goods and enhance livelihood benefits for indigenous peoples and local communities.

1.3.1 CITIES AND URBAN AREAS

Over half the world's population lives in towns and cities. By 2050, it is estimated that more than twice as many people will be living in urban (6.7 billion) than in rural settings (3.1 billion).[147] Cities and urban areas generally have dense populations in which the natural environment has been transformed into a built environment governed by complex social and economic interactions.[148] [149] As a result of artificialization, heavy rains can quickly turn into flash floods. Without enough trees to give shade and vegetation to absorb heat, cities tend to be hotter than the surrounding countryside. Urban transport and industries emit greenhouse gases and contribute significantly to air and water pollution. Cities also generate huge amounts of solid and liquid waste, which ends up in landfills, wetlands, and the ocean.

Urban Greening

Many cities retain great ecological and biodiversity potential. However, most urban residents rarely encounter nature directly and are unable to understand or appreciate it fully.[150] Urban greening – including creating blue spaces through, for example, riparian and wetland restoration – can be an effective way to engage communities in making their cities more livable and sustainable. Greening activities improve environmental health, economic opportunities, and aesthetic values as well as contribute to improved mental health and a better quality of life in the city.[151] Whether a park for recreation, tree-lined streets and green buildings for cooling, or a wetland area for flood water storage, urban greening frequently offers a confluence of tangible benefits for residents.[152] [153]

FIGURE 1.9 The benefits of creating green and blue spaces in urban areas

URBAN RESTORATION

ACTIONS

GREEN SPACES

- Creating or restoring parks, recreation areas, urban forests, and wildlife habitat
- Planting street trees and vegetative buffers; installing green roofs and walls
- Developing urban farms and community gardens

BLUE SPACES

- Creating or restoring rivers/streams and lakes/ponds
- Retrofitting for rainwater harvesting and better infiltration
- Improving water and waste management and recycling

BENEFITS

Food security, nutrition, and income: Urban farms, fishponds, and community gardens ensure greater food availability and generate extra income, especially for women.

Microclimate regulation: Parks, street trees, riparian corridors, green roofs, and walls provide shade, absorb carbon and pollution, and reduce the urban heat island effect.

Water regulation: Trees, vegetation, wetlands, and permeable soils reduce runoff and the risk of flooding; they also contribute to water recycling and treatment, lowering pollution and costs.

Recreation and human health: Vegetation and water bodies improve air and water quality; parks and gardens promote exercise and relaxation, boosting physical and mental health.

Biodiversity habitat: Restored natural features can support a mosaic of habitats with a relatively high diversity of plant and animal species, especially when there is greater ecological connectivity.

Efforts to make cities greener and more sustainable are gaining momentum around the world. Nature-based solutions for water treatment, temperature control, and flood mitigation are practical options when decommissioning or replacing ageing urban infrastructure.[154] Protecting and restoring nature is extremely cost-effective when planning and designing new urban and peri-urban developments.[155] Many urban greening activities are labor-intensive and bring people together for a common purpose, providing for shovel-ready jobs (e.g., soil preparation, engineering, tree planting) as well as more permanent employment opportunities (e.g., maintenance, management).

Urban Food Production

A significant amount of food is produced in urban areas – in backyards, private, or community gardens and allotments, on roofs and balconies, in greenhouses, and on city farms. Urban agriculture increases incomes and food security by providing healthy and plentiful substitutes for purchased food, especially for poor households. They are also more likely to have access to a wider variety of nutritious foods and be more resilient to food price increases. It is estimated that urban agriculture has the potential to produce 10% of the global output of legumes, roots/tubers, and vegetable crops.[156] In addition, many urban households in developing countries raise poultry and livestock for additional food security and household income.

Urban agriculture does not just produce food – it is a nature-based solution to many social and economic problems in cities and towns around the world.[157]

Trees and Ecological Connectivity

Trees and woodlands in cities act as natural temperature buffers by providing shade and reducing the heat island effect. They help reduce noise pollution, energy use, and carbon emissions; produce timber, fuelwood, fruit, and nuts; and provide critical habitat for wildlife, especially birds. Vegetated and riparian corridors within and around cities create buffer zones for recreation as well as migration corridors for wildlife. Wetlands and restored waterways are important hydrological connectors in and around cities that help control floods, regulate seasonal flows, and provide clean drinking water to urban residents.

Human Health and Recreation

Gardens, parks, and other green spaces enhance the mental and physical health of urban residents. They provide outlets for relaxation, recreation, and exercise – and can serve as outdoor classrooms for environmental education. Allotment gardens and public parks are especially important to low-income residents who do not have private gardens or are unable to travel outside the city. Many noncommunicable diseases (e.g., water/air borne) in urban populations are linked to poor infrastructure and degraded microbiota diversity.[158] Green and blue infrastructure can deliver vital services at low cost and at the same time restore biological diversity in the urban environment.

Urban Land Governance

How land is governed in urban areas depends on a network of actors and relationship dynamics. For example, local politicians decide on regulations and new development. Municipal planners demarcate zones for industry, residences, retail, green space, infrastructure, and other uses while attempting to reconcile competing needs. Architects and designers plan offices, shops, and homes. Developers and landowners finance and build properties. Tenants pay rent to control a small parcel or inhabit an apartment. It is this archetypal dynamic that governs the options for urban greening.[159]

When designing urban restoration initiatives, it is essential to involve the local community – i.e., those who benefit directly, who will be most affected, and on whom success depends. In some cases, national governments may devolve more power and financial resources to local authorities to fund and support participatory urban greening initiatives.[160] Municipal governments and local administrations are better able to ensure that their communities are fully engaged in the planning, implementation, and maintenance of these greening activities.[161]

Women and Youth

Women can play a major role in urban greening. They are often involved in informal and local food markets, and many are engaged in urban agriculture to boost food and nutritional security as well as household incomes. Ensuring they have more secure tenure and resource rights, and improving their access to credit and services, can help create valuable employment opportunities for women and inspire new entrepreneurship. Greater control of finance and technology would also result in greater equity and empowerment for women in urban areas.[162]

Urban areas are a magnet for youth and can be a springboard for engaging in restoration. By 2030, about 60% of urban residents will be aged under 18.[163] These young people can lead the next generation to create greener and more sustainable urban environments. They would care for forests and parks, revitalize landfills and brownfields, and manage organic farms and gardens. Urban restoration projects, supported by educational and school programs, not only educate youth about environmental and sustainability issues but provide them with the training and skillsets needed to pursue meaningful work or become ecopreneurs.

© Clement Tardif_Feed the Future_Senegal_Yaajeende

1.3.2 URBAN–RURAL INTERFACE

The areas immediately surrounding towns and cities are often seen as transitional – neither fully urban nor completely rural. While providing vital services to the core urban area, such as food, water, and recreation as well as housing and transport links for commuters, these areas are also susceptible to further urban expansion and artificialization. Conversely, core urban areas offer employment, public services, and markets for those who live at the interface.[164]

Urban-rural linkages are the reciprocal and repetitive flow of people, goods, and financial and environmental services between urban, peri-urban, and rural locations.[165]

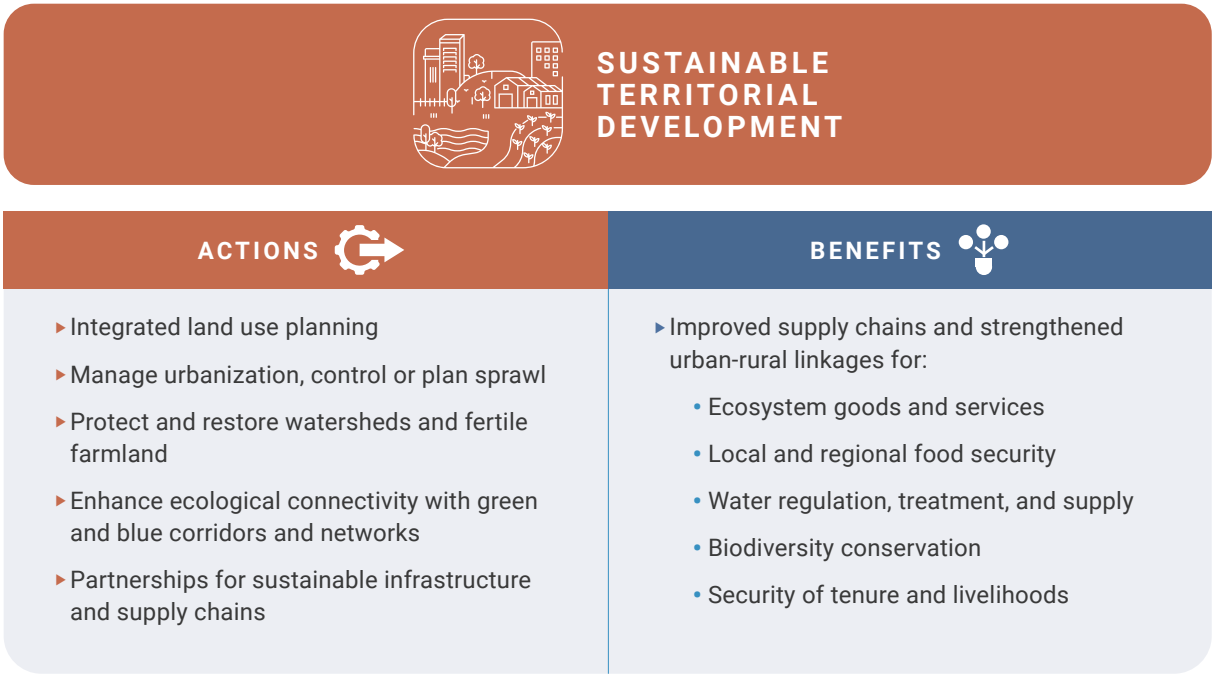
Urban Expansion

Urban expansion, whether planned or not, results in land use change and the loss of ecosystem services. Many cities around the world are surrounded by agricultural land that is more productive than the national average. Urban expansion by 2030 will likely cause a 1.8-2.4% aggregated loss of croplands globally, with losses as high as 80% in some peri-urban areas in Asia and Africa.[166] The conversion of fertile agricultural land is likely to be accompanied by losses in natural fragments and ecosystems at the interface.

Globally, urban areas have more than doubled in size in just decades, from 33 million hectares in 1992 to 71 million hectares in 2015. This expansion has consumed 24 million hectares of croplands, 3.3 million hectares of forest, and 4.6 million hectares of shrubland. The associated indirect loss of natural ecosystems was considerably larger due to this cropland displacement, estimated to be 18-32 million hectares of forest and 7-17 million hectares of shrubland.[167]

More secure tenure arrangements in peri-urban informal settlements would help boost stability, security, and sustainability for more than 15% of the global population. Over 1 billion people live in informal settlements, with 80% of them located in Asia and sub-Saharan Africa. While these settlements lead to urban expansion, land is not properly demarcated and registered, and boundary conflicts are frequent. These residents are typically poor and unwilling to invest in their homes and land without the certainty and confidence afforded by secure tenure.[168]

FIGURE 1.10 The benefits of sustainable territorial development



Preserving Ecological Integrity

Most native vegetation in the urban-rural interface has already been fragmented, cleared, or converted for agricultural or industrial use; in some cases, it is sustainably managed. One key pillar of the restoration decade is to conserve what remains of the natural world and improve its connectivity in the landscape. Conserving and restoring these natural areas and fragments through the enhancement of green and blue infrastructure can help form a stable land use mosaic to meet urban demands for food, energy, biodiversity, flood protection, water supply, recreation, and carbon sequestration.[169]

Watershed Conservation

Conserving and restoring urban source watersheds is a high priority for many city governments. The degradation and loss of grasslands and forests create major problems for cities that depend on these source watersheds.[170] They provide many essential ecosystem services, not just the delivery of good quality drinking water to urban residents. One important tool to protect these watersheds is enforceable regulations that require landowners and planners to mitigate the downstream impacts of their land use and management practices. Restoring native flora and fauna in these watersheds is a proven and cost-effective way to preserve vital hydrological functions, such as water percolation, filtration, and flows – both above and below ground.

Territorial and Landscape Planning

Many cities grow unplanned with poor infrastructure development that can result in congestion, pollution, lower water tables, and a lack of amenities and green space. Municipalities, their suburbs, and surrounding rural areas are often governed by different local authorities competing for resources and revenues. As cities expand, a lack of coordination and planning among these authorities is an important factor that hinders the provision of adequate infrastructure, the conservation of productive farmland, and the preservation of natural areas.

Territorial planning is an administrative tool for rational land allocation and the development of green and blue infrastructure to strengthen urban-rural linkages. This typically involves relevant local authorities coordinating sectoral plans as a coherent unit and engaging with relevant stakeholders in zoning decisions that balance artificialization with the preservation of farmland and natural areas. Effective territorial planning can reshape the form and function of urban-rural linkages to generate economic growth and secure employment while addressing the needs of vulnerable groups.[171]

Land readjustment, land sharing, land consolidation, or land pooling refers to schemes where the local authority pools land from multiple landowners and reallocates it for more rational development at the urban-rural interface. The landowners get back a smaller, but more valuable parcel of land because of improved infrastructure (e.g., transport, electricity, sewage) and access to green and blue space and related amenities.[172]

Territorial planning can also encourage the development of shorter and more efficient supply chains that reduce pressures on land resources further afield. Peri-urban areas are often well-positioned as distribution points for regional produce and value-added commodities that supply lucrative city markets. Other measures to strengthen sustainable urban-rural linkages include the development of more efficient transport and energy infrastructure, payments to peri-urban farmers for ecosystem services, and the certification and labeling of regionally produced goods, including favorable local procurement policies for government offices, schools, hospitals, and prisons.

© Rafi Respati

1.3.3 RURAL AND AGRICULTURAL LANDSCAPES

Rural and agricultural landscapes are typically dominated by croplands, pastures and rangelands, orchards and plantations. They contain relict patches, fragments, or corridors of natural vegetation that can often be found on steep slopes or poor soils, along rivers, and in wetlands. When these are protected and restored as part of an integrated landscape mosaic, rural areas can increase biodiversity values while providing essential services to farmers, like pollination or pest control. These services depend not just on agricultural practices, but also on the mix of land uses, management approaches, and their ecological connectivity in these working landscapes.

Status and Trends

Food systems are currently the single greatest driver of terrestrial natural capital loss. Crop and grazing lands now cover more than five billion hectares, almost 40% of the Earth's land surface.[173] The ongoing destruction of nature for food production (i.e., extensification) is now encroaching on some of the most species- and carbon-rich ecosystems on the planet. While agricultural intensification can increase yields in the short term, unless done in a sustainable manner, it tends to cause high levels of land and soil degradation and contamination. Faced with long-term declines in productivity and water scarcity, farmers paradoxically resort to the increased use of harmful agrochemicals and inefficient irrigation systems.

Rainfed farming produces 60% of the world's food on 80% of the cultivated land whereas irrigated agriculture accounts for the balance.[174] Shifting weather patterns and greater rainfall variability due to climate change threaten food production in many rainfed areas. Responsible land governance (rights), targeted investments and incentives (rewards), and farsighted policies and planning (responsibilities) will be critical to accelerate the transition to nature-positive food production that regenerate soils, conserve water, and enhance farm resilience.

Nature-Positive Food Production

Agriculture will continue to be a key economic sector but will require a transition to nature-positive food production that involves the regenerative, non-depleting, and non-destructive use of natural resources.[175] Agroecological approaches and regenerative practices explicitly aim to enrich soils, improve water regulation, and augment biodiversity. Many of these holistic practices are based on indigenous, traditional, or local knowledge, which embeds the social, economic, and environmental dimensions of sustainable development into food production. Nature-positive food production is also people- and climate-positive, delivering healthy, affordable, and nutritious food while supporting decent livelihoods and reducing emissions.

Regenerative agriculture can only be efficient and effective when based on evidence, knowledge, and science tailored to local needs, context, and conditions.[176] This includes an understanding of the biophysical (e.g., climate, soils, slope, prevalence of pests and diseases) and socio-economic context (e.g., farm size, tenure type, markets, availability of capital).[177] Each region, farm, and field will employ its unique combination of regenerative measures. For many small-scale producers, crop and livestock diversification is key to improving resilience and productivity while reducing environmental risks, especially in areas with declining soil health.[178]

In the developing world, integrated systems are more common and typically involve a mix of crops, livestock, and trees along with the production of non-food commodities and the recycling of farm by-products for agricultural inputs.


© Ana Christina Chaclán García

FIGURE 1.11 Regenerative agriculture: Linked processes to achieve multiple outcomes

REGENERATIVE AGRICULTURE

ACTIONS

- Measures that enhance soil organic carbon, nutrient, and water availability
- Integration of crops, trees, livestock, and aquatic foods
- Recycling of nutrients and other inputs on farm (increased efficiencies)
- Soil and water conservation techniques

BENEFITS

- Food security, nutrition, and rural livelihoods
- Healthy soils and ecosystem functions
- Carbon storage and reduced greenhouse gas emissions
- Water quality, supply, and recharge
- Biodiversity conservation
- Human and animal welfare

Conservation Agriculture

Conservation agriculture increases biomass and soil organic carbon as well as nutrient and water availability through agronomic and other resource-conserving practices. Tillage – turning over the soil – weakens many of its functions and releases carbon into the atmosphere. Conservation agriculture combines no- or low-till cultivation with measures like direct/drill seeding, cover crops, mulching, intercropping, and fallow periods. These practices protect soil structure, conserve moisture, suppress weeds and pests, and can create new carbon sinks over longer time scales.[179] Some forms of conservation agriculture accept the judicious use of agrochemicals.[180]

Agroforestry, Silvopasture, and Pastoralism

Agroforestry and silvopasture systems combine vegetation management (primarily trees) with crop and livestock production. Trees and shrubs on agricultural land can produce direct economic benefits, like fruit, seeds, latex, oil, fodder, timber, or fuelwood. They can also provide mulch for crops, improved forage and shade for livestock, and habitat for wildlife. The use of trees/shrubs in crop and pasture lands is effective in boosting soil health and protecting it from water and wind erosion.[181]

Pastoralism refers to livestock management over large distances. It can be an efficient way of utilizing highly variable rangeland resources, especially in the drylands and high-altitude ecosystems. Pastoralists adapt their social and herding systems according to seasonal conditions and the availability of water and pasture. Sustainable pastoralism works to leverage natural synergies and align food (e.g., meat, dairy) production with ecological processes, reducing input costs and harmful externalities (i.e., the off-site cost and harm to people, climate, and the environment).[182]

Combining science, tradition, and innovation, organic and permaculture methods enrich biodiversity and restore agroecosystems to provide food and nutritional security for local communities.[183]

Organic Agriculture and Permaculture

Organic cultivation and herding were the predominant method of food production for millennia. Modern organic food production excludes the application of chemical fertilizers and synthetic pesticides as well as genetically modified organisms, growth hormones, and antibiotics.[184] Many of the practices are based on traditional methods that utilize compost, green/animal manures, crop residues, water harvesting, vermiculture, and mineral additives to produce healthy and nutritious foods. Similarly, permaculture takes a systems approach to farm design that mimics natural processes and works within ecological boundaries.[185] With increasing levels of contamination in food systems, organic produce is widely valued for its superior quality and safety. This attracts a sustainability premium – a reward to producers for having a smaller environmental and climate footprint than modern industrial agriculture.[186]

Soil and Water Conservation

Soil and water conservation measures include many of the practices described above. In addition, physical interventions can be undertaken, such as contour or terrace farming on steep slopes to conserve rainwater and reduce soil erosion. When these relatively simple structures are maintained, water management solutions can be relatively cheap whereas mechanical earthmoving for new infrastructure development generally requires more labor and investment. This can include building terraces, drains and retention ditches, ponds, tanks, and reservoirs to harvest and store water, check dams to regulate flows, and more efficient drip irrigation systems.[187]

Climate-Smart Agriculture

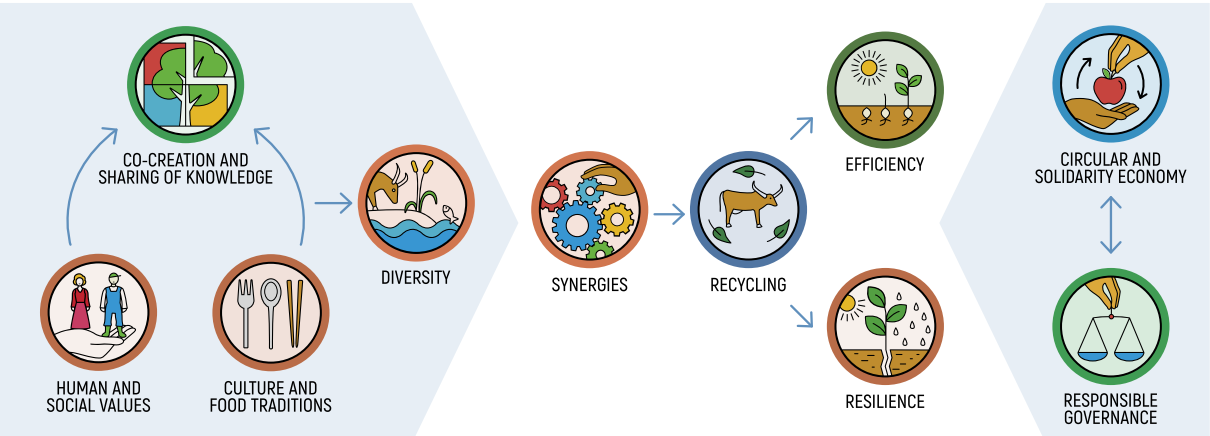
Climate-smart agriculture responds to the need for farmers to mitigate and adapt to climate change. Its three primary objectives are to: sustainably increase productivity and incomes; make food systems more resilient at all scales; and reduce greenhouse gas emissions and sequester carbon.[188] Overall, climate-smart agriculture aims to balance food security and farmer livelihoods with a need to manage climate risks and impacts and respond to changes in the wider food system.[189]

Precision Agriculture

Precision agriculture is guided by real-time data to reduce the use of water, agrochemicals, and labor. It encompasses a growing range of technologies that utilize human, financial, and natural resources more efficiently, including artificial intelligence and geographic information systems, remote sensing, and mobile applications. These technologies enable producers to carefully manage crops and livestock by optimizing the use of fertilizers, pesticides, feed, and water.[190]

While precision agriculture is often marketed as a new paradigm, it is grounded in many of the same principles of observation and adaptive management used by farmers for millennia.[191]

FIGURE 1.12 Agroecological transition to sustainable and resilient food systems



Source: Barrios et al., 2020.

Governing Agroecological Transitions

The collaborative management of natural resources in rural and agricultural landscapes is a widespread and ancient practice. Modern farmers form cooperatives to maintain natural buffer zones, share input costs, negotiate prices, and increase access to markets for their produce. These arrangements allow them to benefit from peer-to-peer exchanges on field-level innovations. Collaboration becomes more challenging in a larger mosaic of land uses and governance regimes where there may be significant competing interests or power imbalances among actors and institutions.[192]

Achieving a balance between rural development and ecological preservation requires active participation by individuals and communities who directly relate to the land.[193] However, many farmers and rural land users often have insecure rights to their land and/or resources, making them less willing to invest time and money in agroecological approaches and regenerative practices. External drivers and pressures on farm-level decisions also play an important role in any transition to sustainable agriculture, most notably the pricing mechanisms and incentives in both input and output supply chains.

Consumers that pay a premium for sustainably produced food and land-based commodities can drive increased adoption of regenerative agriculture practices. Their choices send powerful market signals down the supply chain to retailers, processors, and ultimately producers. These demand-side pressures can help farmers to capture a greater share of the added value of organic or sustainable produce. They also put pressure on retailers and suppliers to meet new consumer demands, which may improve compliance with their own environmental, social, and governance standards. Public opinion and civil society can help persuade governments to play a more active role in promoting certification schemes, enforcing sustainability standards, and transitioning to more sustainable procurement practices.

© Ana Christina Chaclán Garcia


© Neil Palmer_CIAT

1.3.4 NATURAL ECOSYSTEMS

Natural ecosystems, along with protected areas, still cover large areas of the planet and encompass a wide range of climatic and vegetation types. From deserts, mountains, and tundra to forests, grasslands, drylands, and wetlands, they are often home to – or managed by – indigenous peoples and local communities. They are globally significant in terms of their biodiversity habitat and their ability to store carbon and regulate other important biosphere functions.

Forests and Grasslands under Threat

Between 2000 and 2015, 5 to 10 million hectares of forest were destroyed every year, leading to a cumulative global loss of 125 million hectares (an area twice the size of France). Hidden in the numbers is the loss of biodiverse and carbon-rich tropical forests, which has been offset by an almost fivefold increase in the rate of expansion of temperate forests.[194]

Between 2013 and 2019, it was estimated that at least 69% of tropical forest clearance for agriculture was conducted in violation of national laws or regulations (32 million hectares or an area the size of Norway).[195] The unlawful clearing of these forests, primarily for cattle, palm oil, soy, and pulp plantations, is fueled by short-sighted national development priorities, a lack of regulatory enforcement, global trade incentives, and ultimately consumer demand in developed countries.

Grasslands face the greatest threats from agriculture expansion and climate change. Conservative scenarios predict that an additional 300 million hectares of forests and other natural ecosystems will be destroyed between 2015 and 2050, mostly converted to cropland.[196] In the wetter regions, grasslands are the largest source of land being converted to cropland, accounting for 68% of the total extent of agricultural expansion in 2015. On the drier margins, grasslands accounted for 35% of the increase in barren land, in some cases leading to desertification.[197]

Dams and Mining

The damming of rivers produces dramatic and far-reaching environmental changes. The disruption of hydrological connectivity affects riparian and floodplain morphology and vegetation, resulting in the loss of biodiversity, fertile land, and human settlements. While dams can provide a variety of services – hydropower, flood control, navigation, and water supply – the creation of large reservoirs significantly alters local and regional climate, soils, flora, and fauna which fragment critical habitat and impact species migrations.

Mining for metals, minerals, and fossil fuels occurs in all land types, with natural and protected areas experiencing the highest land degradation as a result. Extracted commodities include rare earth metals for smartphones and electric batteries, phosphorus for agriculture, sand and gravel for construction, coal and natural gas for power plants, and crude oil for transport. Mining typically involves the removal of soil and vegetation, the building of infrastructure that leads to biodiversity loss, and the release of methane gases. Improper storage of mining waste can result in spills and leaks of hazardous materials that lead to soil, ground and surface water contamination.

FIGURE 1.13 Actions and benefits for the conservation and restoration of natural ecosystems

CONSERVATION AND RESTORATION OF NATURAL ECOSYSTEMS

ACTIONS

- Avoid agricultural expansion and promote sustainable management and harvesting
- Scale up natural regeneration and active restoration (forests, grasslands, landscapes)
- Improve grazing and rangeland management
- Protect and restore peatlands and other wetlands
- Reduce impacts of dams and mining
- Embrace indigenous and community-based management

BENEFITS

Local services: water regulation, human health, climate, recreation, and disaster risk reduction

National assets: ecotourism, agricultural heritage, cultural landscapes

Global public goods: climate and hydrological stability, biodiversity conservation

Restoring Natural Ecosystems

Native ecosystem recovery – ecological restoration and rewilding – aims to reinstate historic conditions for ecological functioning and populations of flora and fauna. Restoring an ecosystem to a more natural state requires a clear understanding of past land use, the current drivers of degradation, and current management practices.[198] Recovering the full ecological potential of native ecosystems is a challenging long-term process. For example, a transition from abandoned agricultural land to sustainably managed forest could take 20 years or more.[199]

Passive vs Active Restoration

In some cases, it is enough to remove drivers of degradation, such as overgrazing, nutrient pollution, unsustainable logging, or invasive species. Passive or natural regeneration can allow an ecosystem to recover when disturbance is minimal, or when there is adequate connectivity with surrounding natural fragments to allow for seed dispersal and genetic exchanges. **In other cases, active restoration is required.** This is generally more costly and involves sustained interventions, such as planting native species, reinstating hydrological functions, or reintroducing locally extinct animals. In natural ecosystems with a long history of human management, ecological restoration may include returning to or adapting traditional regenerative practices.

Forest Restoration

Natural regeneration is often the first best option for ecosystem recovery, especially in tropical forests.[200] Like active restoration, it still needs to be rigorously managed by local communities to help bring back natural processes that contribute to the health and productivity of forests. If recovery is slow, then active restoration measures can be taken to overcome specific obstacles.[201] This may involve seed collection and establishing nurseries, planting native trees and vegetation, managing tree density and undergrowth, reintroducing endemic species, and improving wildlife corridors. Successful forest and landscape restoration often depends on having the right incentives in place to ensure collaboration among a wide range of stakeholders.

Grassland Restoration and Grazing Management

Degraded grasslands can be restored using a variety of methods and techniques. These include reseeding with native grass species, recovering soil biodiversity and controlling erosion, grazing management (particularly around water sources), and planting suitable trees and shrubs to provide forage, shade, and fuelwood. The growth of invasive species (e.g., unpalatable species, woody shrubs) can be contained through selective thinning and controlled burns that promote native regrowth. Exclosures (i.e., areas protected from grazing) and rotational grazing, or even continuous grazing with low stocking rates, are proven methods for restoring grassland health and productivity (e.g., improved soil structure, water retention/infiltration), even more so when they are managed to enhance connectivity within the wider landscape.[202]

Dryland Restoration

Drylands – arid, semi-arid, and sub-humid areas covering more than 40% of the land surface – meet the basic needs of one in three people in the world but are under serious threat. Drylands support 50% of the world's livestock, provide essential wildlife habitat, and account for nearly half of all cultivated systems.[203] They are a major contributor to the world's breadbasket, considering that one in every three crops under cultivation today has its origins in the drylands, where their wild ancestors and relatives still grow. Drylands harbor some of the most valuable and rarest species of flora and fauna. With the right support and the adoption of scalable strategies, low-cost and effective restoration practices in the drylands have great potential for boosting incomes and livelihoods, ecological and economic resilience, and climate change mitigation.[204]

Protecting and Restoring Peatlands

Peatlands provide the most efficient natural store of terrestrial carbon – holding twice as much as global forest biomass – and deliver many valuable ecosystem services. Although they only cover 3% of the total land area, when degraded or drained, peatlands oxidize and are susceptible to fire. This contributes disproportionally to greenhouse gas emissions, which currently represents one-quarter of the total emissions released by the land use sector. It is suggested that the land system could turn into a global net carbon sink by 2100, if 60% of degraded peatlands are rewetted (restoring natural water flows and soil saturation) and currently intact peatlands are protected.[205]

Governance Issues

The destruction of forests, grasslands, and peatlands for agriculture, mining, or industrial uses is often deemed necessary for economic development – creating jobs and foreign exchange. Whether privately, publicly, or communally owned, natural areas are often treated as a state asset whereby economic exploitation can ignore or override existing regulations and land use rights. This occurs when loggers, ranchers, and farmers move into areas of tropical forest or peatland, or when sedentary dryland communities begin growing crops on traditional grazing lands. This can give rise to newly contested areas that are prone to conflict and violence and, in some cases, subject to land grabs that are overlooked or tacitly sanctioned by local authorities or the state.

Human-wildlife conflict poses a challenge to conservation and restoration efforts as both humans and wildlife are losing the space and resources they need to survive.[206] Restoring natural areas and wildlife habitat and respecting protected area boundaries can provide the necessary buffer zones to better manage human-wildlife conflict.

Land degradation in natural ecosystems can take place when encroachment disturbs traditional or sustainable management and harvesting practices. Indigenous peoples and local communities have a long tradition of managing and extracting natural resources without compromising ecological processes and functions. Customary uses may include sustainable pastoralism, small-scale slash-and-burn agriculture with appropriate rotations, or the harvesting of wild plants and animals for food, energy, fiber, and housing. To avoid further land degradation, governance and enforcement mechanisms can strengthen tenure rights in natural areas or designate them as indigenous and community territories or conservation areas. The right to free, prior and informed consent is an internationally recognized mechanism by which indigenous peoples and local communities can enjoy the economic benefits derived from their traditional knowledge and stewardship of the land.

1.3.5 **PROTECTED AREAS**

Protected areas harbor irreplaceable ecological, social, and economic values. Some are very large, while others are relatively small situated within a mosaic of land uses. Categories of protected areas vary widely, from strict nature reserves with no permitted human activities to areas that allow the sustainable use of natural resources.[207] They provide refugia and buffers for many species against the combined effects of climate change and habitat loss.[208]

The rich biodiversity in protected areas underpins a vast array of private and public goods and services, such as reducing disaster risks, preventing future pandemics, and mitigating/adapting to climate change. It is their ecological integrity and functioning that makes protected areas effective conservation tools, not necessarily their size.[209] Many indigenous peoples and local communities live in and around protected areas – the creation of new or expansion of existing protected areas should not deny people access to the resources they depend on.

Protected areas are the source of 20% of all continental surface water runoff, potentially supplying freshwater to two-thirds of the global population.[210]

Status and Threats

Protected areas currently cover around 17% of the world's ice-free land surface, an increase from about 10% in 2000.[211] The majority of these areas include forest ecosystems, which have had the effect of slowing deforestation rates in some regions; however, most of these areas are still far from being adequately protected.[212] Protected areas include roughly two-thirds of the 15,000 Key Biodiversity Areas, recognized for their contribution to the global persistence of biodiversity.[213] In mega-biodiverse countries – those that host exceptionally large numbers of species – protected areas are essential factors for a stable climate and a healthy planet.

Designation and legal status are not enough to prevent degradation and encroachment in protected areas. Improved management and enforcement are needed to counter powerful groups and disenfranchised communities who can find entry points for both economic and subsistence activities. In protected areas that offer grazing or are endowed with high-value natural resources – metals, minerals, hardwoods, or wildlife products – enforcement can be challenging due to corruption, violence, and lack of funding. The remoteness and inaccessibility of some protected areas further hinder their effective governance and management.

Protected areas help mitigate climate change by sequestering carbon and avoiding emissions that typically result from ecosystem degradation and loss.[214] Nevertheless, climate change is causing many plant and animal species to shift towards higher altitudes and latitudes, at the same time, habitat loss and fragmentation impedes their ability to do so. In some cases, the fixed boundaries of protected areas may lessen their capability to safeguard species from increased temperatures, invasive species, and rainfall variability.[215]

FIGURE 1.14 Actions and benefits for restoring, connecting, and expanding protected areas

CONNECTING, RESTORING, AND EXPANDING PROTECTED AREAS

ACTIONS

- Collaborative management, monitoring, and enforcement
- Incentives for community management and payments for environmental services
- Tenure and resource rights that promote sustainable harvesting
- Restoring native habitat, wildlife corridors, and buffer zones
- Expanding of protected area coverage

BENEFITS

- Ecosystem services: local, national, and global public goods
- Biodiversity habitat conservation, prevention of species extinctions
- Ecological connectivity and reduced stress on flora and fauna
- Incomes, livelihoods, and recreation
- Landscape and cultural diversity

Restoring Protected Areas

It is suggested that half of the world's land surface would have to be effectively protected to halt the extinction crisis and maintain planetary life support functions.[216] Many existing and new protected areas have great potential for affordable biodiversity conservation and restoration without compromising livelihoods and sustainable development. Even those protected areas, already severely or moderately degraded, still have a legacy of climate and soils, flora and fauna, seeds and genetic materials that can assist ecological restoration efforts.[217]

Protected areas are often the only remaining habitats for vulnerable or keystone species, and restoration may be needed to maintain or bolster these threatened populations.[219] Complete recovery of native habitat – the aim of ecological restoration – is more likely in protected areas when there is local knowledge and expertise, community involvement, and minimal degradation. Although a secondary objective, the recovery and maintenance of ecosystem services are often co-benefits of restoration activities, such as climate stabilization, pest and disease regulation, disaster risk reduction, and food and water security.[220]

Restoration is likely to become a more common and necessary conservation tool to address land degradation and biodiversity loss and to re-establish connectivity between protected areas and fragmented habitats.[218]

© Greg Shine, BLM

Ecological connectivity is the unimpeded movement of species and the flow of natural processes that sustain life on Earth.[221]

Boosting Ecological Connectivity

Well-connected protected areas are critical for important ecological processes, including species migration, seed dispersal, and gene flows. Globally, just under 10% of the area under protection is considered structurally connected with functional pathways throughout ecosystems and landscapes.[222] [223] As a result, wildlife is increasingly confined to rare and sparse habitat fragments – often forming small and isolated populations that are vulnerable to stresses, shocks, and local extinctions.[224] Greater emphasis should be given to the ecological representativeness, connectivity, and effective management of protected areas rather than on the total area covered.[225] [226]

Beyond their boundaries, protected areas can create buffer zones – creating a halo effect – reducing land use change and deforestation in surrounding areas.[227] This de facto protection, even if only transient in extent and duration, can help defend the core protected area from encroachment and degradation. Some of these buffer areas may have other forms of conservation status and are often managed by indigenous people and local communities that are dependent on protected area resources for food, medicine, and other essentials.

Inclusive Governance and Finance

Protected areas provide public goods that are vital not only for local communities, but also for the country, region, and the world.[228] Some developing countries are making significant efforts to safeguard protected areas for the sake of the global commons even as they struggle to reduce poverty and hunger.[229] These include alternative governance arrangements, such as 'other effective area-based conservation measures' (OECMs) which lack formal designation but are typically governed by indigenous peoples and local communities, sometimes referred to as Indigenous and Community Conserved Areas (ICCAs).

Protected areas can also support green jobs and be engines of growth, yet currently remain vastly under-resourced. An alternative to government funding involves finding the means for local inhabitants to be employed or paid to maintain their biodiversity values and safeguard the delivery of ecosystem services.[230] This could increase the prospect of international funding, including philanthropic donors, especially for the maintenance of public goods that are enjoyed at regional and global scales.[231] While these types of finance can be challenging, the ensuing social and economic benefits are often sufficient to compensate local communities for the effective management and restoration of protected areas.[232] [233]

Ecotourism is another opportunity to improve livelihoods within and adjacent to protected areas.[234] Many protected areas feature spectacular landscapes or charismatic megafauna while others offer subtler, but equally valuable recreational experiences. Ecotourism encourages innovation and entrepreneurship, provides local jobs, and supports government revenues while advancing important conservation objectives, especially in neglected and remote rural areas.[235] For example, charging user fees can have a large multiplier effect, including employing and empowering local communities to responsibly manage the land and deter illegal use or encroachment.

Countries with lower agricultural activity, higher economic growth, and better governance are most strongly associated with greater management effectiveness in protected areas.[236]

1.4 RECOVERY AND RESILIENCE

The COVID-19 pandemic has triggered the most severe global economic recession in nearly a century. Two years later, it continues to impact people's lives and livelihoods. Developing and low-income countries are the hardest hit, with the pandemic compounding existing development challenges – extreme poverty, violent conflicts, food shortages, and climate-related emergencies. The pandemic has also put a spotlight on the consequences of shrinking wildlife habitat and environmental degradation. SARS-CoV-2, the virus strain that causes COVID-19, is widely thought to have originated in wild animals and jumped to humans, just like the coronaviruses SARS and MERS. Human encroachment on the natural world and the growing wildlife trade makes these leaps easier and more frequent.[237]

As the planet continues to warm, drought, floods, wildfires, and sand and dust storms are becoming more frequent and intense, jeopardizing human health and livelihoods, food systems, and socio-economic stability.[238] Disaster impacts are now evident in all parts of the world. Land restoration offers multiple pathways to support recovery efforts and reduce future vulnerabilities by regenerating natural capital and building green and blue infrastructure that strengthens community and ecosystem resilience. Strong partnerships and coordination between governments, businesses, and communities, as well as at all levels and across multiple sectors, will set the stage for inclusive green recovery and long-term planning and finance to address growing risks to lives and livelihoods.

© World_Bank_Guinea

1.4.1 INCLUSIVE GREEN RECOVERY

The COVID-19 pandemic plunged most countries into recession, with an estimated 90% of the world's workers affected.[239] It has wiped out decades of progress in reducing poverty and hunger. Jobs and livelihoods in developing countries with large informal sectors have been most impacted, especially women and youth, and agricultural and migrant workers.[240] Almost 100 million more people sank into poverty in 2020,[241] and an additional 118 million people experienced hunger.[242] In response, many developed countries have implemented robust economic recovery packages. Despite being the greatest expenditure of public resources ever, only 10% of the total USD 17 trillion in stimulus provided since the start of the pandemic has been spent on activities that reduced greenhouse gas emissions or restored the natural world.[243] [244]

A lack of resources to implement stimulus packages has hindered recovery in many developing countries. While there have been some recovery efforts, inequalities will continue to increase among and within nations without urgent action. This makes more people poor and vulnerable to communicable diseases and other disasters, stresses, and shocks. An inclusive green recovery goes beyond balancing growth and protecting the poor to deal with disenfranchisement and long-standing systemic inequalities.[245]

Learning from the Past

The relatively few green stimulus measures implemented in the aftermath of the 2008 financial crisis produced greater returns on investment than conventional, resource-intensive projects.[246] The evidence suggests that a low-carbon, green recovery could contribute to significant reductions in emissions while creating jobs and nature-positive economic growth.[247] Two important lessons emerged from the 2008 crisis: that short-term fiscal stimulus is not enough and long-term public spending is needed; and that wealthy countries are best positioned to lead on green innovation and technologies, while developing economies should focus on reducing poverty and land use change.[248]

Green recovery packages will have different starting points that are determined by prevailing social, economic, and political realities, yet the building blocks are prosperity, health, nature, justice, and transformation. Previous efforts have failed in large part because of their focus on reviving business-as-usual rather than building a new economic framework needed for a more resilient future.[249] As the world transitions from stimulus to regular budgeting, governments must continue to use fiscal tools to promote cleaner, greener, and more equitable economic development. While finance will always be a major constraint, most governments are aware of the potential for green stimulus to:

- create **long-term economic multipliers** through investments in green jobs and infrastructure[250]
- implement **shovel-ready restoration projects** and other **nature-based solutions** across economic sectors
- **decarbonize economies** and shift emissions trajectories towards net zero

By investing just USD 2.7 trillion per year in ecosystem restoration, regenerative agriculture, and circular business models, the global economy could create 395 million new jobs and generate over USD 10 trillion in annual business value over a decade.[251]

Redirecting Investments and Incentives

In addition to incentives, such as more inclusive governance and tenure security, financial investments from both public and private sources will have to increase significantly to achieve the promise of the land restoration agenda. While there has been public sector investment in research and extension services to promote regenerative practices, the uptake of sustainable land and water management by farmers and other land managers remains low due to concerns with profitability and incongruence with their experiences and values.[252] For many of the ecosystem services generated through these practices, markets are not structured to accommodate supply and demand, facilitate trade, or adequately establish price mechanisms.[253]

Payments for Ecosystem Services (PES) schemes are an attempt to institutionalize a brokerage system for non-market ecosystem services that are enhanced by land restoration. One challenge is that the service providers (e.g., farmers, land, water, and protected area managers) are often distant from the beneficiaries (e.g., industry, consumers), making it difficult to connect supply and demand with equitable pricing mechanisms. Debt-for-nature swaps, carbon credit schemes, and ESG investment funds channeled through the agriculture and forestry sectors also have the potential to finance land restoration activities at large scales.[254] Greater support is needed for institutions and organizations that can broker projects and financing, pool funding, and demonstrate the returns on restoration investments.

Decoupling support from production or linking it to biodiversity, climate, or restoration targets is a pragmatic way to incentivize and scale up the adoption of sustainable land and water management practices.

Realigning Public Sector Finance

Repurposing agricultural support and other subsidies to the land use sector (e.g., water and fossil fuel extraction) represents a multi-billion-dollar opportunity to finance land restoration.[255] Global subsidies for energy, agriculture, water, and fisheries are conservatively estimated at more than USD 4-6 trillion annually.[256] They include direct monetary payments or other benefit transfers that accrue via taxes, laws, regulations, price supports, or other market distortions. Many are considered perverse in the sense that they incentivize land use and management practices that harm humans and the environment and deplete natural resources rather than replenish them. Farm subsidies can be repurposed to increase the uptake of regenerative practices that require more labor but fewer external inputs and less mechanization. Farms adopting these practices are generally more profitable than those that only employ conventional practices.[257]

Some highly indebted countries have taken innovative approaches to fund a green recovery. Debt-for-nature swaps and nature performance bonds are designed to reduce debt payments so that governments can finance green training and job programs.[258] Likewise, ecosystem restoration funds that blend public and private investment can support tree planting initiatives and improved management of protected areas, creating thousands of jobs for women and youth.[259] Ecological fiscal transfers are one way to compensate local governments for protecting and restoring land resources. Like repurposing subsidies, fiscal transfers are an attractive way for national governments to support environmental goals and reward landowners for restoration activities without having to raise tax revenue or ask for new funding.[260]

Responsible Governance Matters

In addition to investment and incentives, targeted policies and programs focused on human rights can address some of the underlying health and economic disparities that the pandemic has worsened. In many countries, this growing inequality has contributed to the loss of trust in leaders and institutions and a fraying of the social contract. Human rights-based, people-centered, and gender-responsive approaches to crisis recovery can help meet the needs of disenfranchised and vulnerable groups. Inclusive governance solutions can be co-created locally to better ensure long term success and establish trusted institutions that can help build bridges that bring people and nations together.[261]

Governments are learning how to better coordinate their efforts through decentralized or 'polycentric' governance, based on partnerships and collaboration among different sectors of society. This is largely in response to a need for place-based strategies for crisis management and recovery, as many countries were forced to adopt flexible and regionally differentiated measures to cope with the impacts of the COVID-19 pandemic. The provision of quality public services to vulnerable groups is now seen as a policy priority, as is enhanced coordination between local and national governments.[262]

The Paris Collaborative on Green Budgeting

Public spending on green infrastructure is an opportunity to align private sector investment with longer-term goals, such as renewable energy provision, biodiversity conservation, and water and waste recycling. This may be in the form of incentives for retrofitted or new climate-resilient infrastructure (e.g., renewal energy farms in agricultural landscapes) or restoring watersheds and wetlands to reduce the costs of water treatment and delivery. Greater certainty over a pipeline of potential projects would allow investors to offer risk capital, invest in capacity building, and help to create healthy capital markets for green infrastructure investments.[263]

The Paris Collaborative on Green Budgeting, hosted by the Organisation for Economic Co-operation and Development (OECD), promotes the important role of domestic budgetary and fiscal policy in resourcing and implementing environmental goals. It assists countries to integrate nature-positive objectives into existing budget processes as well as mainstream climate and environmental goals across policy portfolios, including using fiscal measures, such as environmental taxes, subsidies, regulation, procurement spending, or large-scale infrastructure projects.[264]

Restoration will be the business and spirit of the coming decades – this vibrant economic growth sector has become too large to ignore.[265]

Building a Restoration Economy

Restoration investments are often meant to combine economic growth with an easing of pressures on ecosystems and climate. The global trend of increasing restoration investments is due to a heightened awareness of land degradation costs as well as growing markets for ecosystem services. Decision makers can no longer afford to manage environmental and economic priorities separately. While still operating within existing policy and market structures, countries can pursue their unique restorative pathways that build on existing and emerging capacities to innovate and remain competitive.[266] Investing in restoration is an opportunity to transform degraded landscapes into functional landscapes that deliver co-benefits, including livelihoods and business opportunities.[267]

A more comprehensive accounting of economic output and jobs that includes nature's contribution to people would reveal the true extent of benefits created by the land restoration.[268] In March 2021, governments agreed on an accounting framework to start appraising their natural capital so as to better understand its contributions to economic growth and the importance of protecting it.[269] On the occasion of the formal adoption of the UN Statistical Commission's System of Environmental-Economic Accounting, the UN Secretary-General stated that "no longer will we allow mindless environmental destruction to be considered as economic progress." [270]

Land restoration will be valued as an engine of growth and stability when success is measured not just in financial terms, but against social, environmental, and sustainability benchmarks.

Restoring land and ecosystems will generate employment, deliver economic diversification, reconnect people with their landscapes, and build community trust and reciprocity. This will spur further investment and innovation, along with training and new skill sets for the jobs of the future. While investing in land restoration may be seen as risky and the payback time uncertain, the negative perceptions of restoration costs fall significantly when the full suite of social and economic benefits are properly accounted for.[271]

Leaders can show the courage, wisdom, and foresight to align fiscal stimuli with their commitments to restore land, pivot to a circular economy, and provide for the needs of all their citizens.

With over one billion hectares of degraded land committed to restoration, there are excellent prospects for creating millions of green jobs.[272] The transition to a low-carbon, restoration economy could generate employment for an additional 65 million people by 2030, more than offsetting employment losses in declining sectors and resulting in a net gain of 37 million jobs.[273] These include a wide range of jobs in the agriculture, forestry, energy, and conservation sectors as well as in project design and planning, engineering, landscaping, value-added industries, new technologies, nurseries, and input supply chains.[274]

Just as land restoration is place-based so too are the many associated livelihood benefits and value-added opportunities. Unlike other economic sectors, most restoration jobs cannot be outsourced – investments and their returns directly support the local economy.[275] This could assist rural communities most affected by the pandemic, environmental degradation, and climate change. It can also inspire entrepreneurial activities and stimulate demand for local products and services that deliver long-term multiplier effects that contribute to wider regional development.

© P.Ananth Kannappan

1.4.2 ONE HEALTH APPROACH

The COVID-19 pandemic has reignited an urgent need to address interlinked challenges in an integrated manner, not through singular or linear approaches.[276] It is difficult to consider economic growth successful if it is accompanied by worsening social, environmental, and human health outcomes.The annual cost of future pandemics could be as much as USD 2 trillion – for just 1% of that cost, the world could prevent pandemics at their source by protecting nature.[277]

The One Health approach accounts for the interconnections between people, animals, plants, and their shared environment. It recognizes that the long-term resilience and wellbeing of humanity depends on the health and integrity of nature.[278] One Health covers a wide range of issues, including zoonotic and vector-borne diseases, antimicrobial resistance, food safety/security, and environmental pollution. It can also be effective in addressing chronic disease, mental health, occupational health, and noncommunicable diseases.[279]

One Health embraces multi-level governance to help coordinate preparedness and response plans that bridge multiple sectors. Evidence-based policies, global collaboration, and coordinated actions can advance coherent strategies for restoring health.[280] Land restoration is a clearly identified pathway to preventing future pandemics and mitigating other disasters by repairing damaged ecosystems.[281] Landscapes with high ecological integrity – structural intactness and connectivity, biodiversity and species abundance, and generative interrelatedness – provide higher levels of biosecurity.[283] The rising public health costs associated with disease and disaster can help catalyze a transition towards a restorative culture.[284]

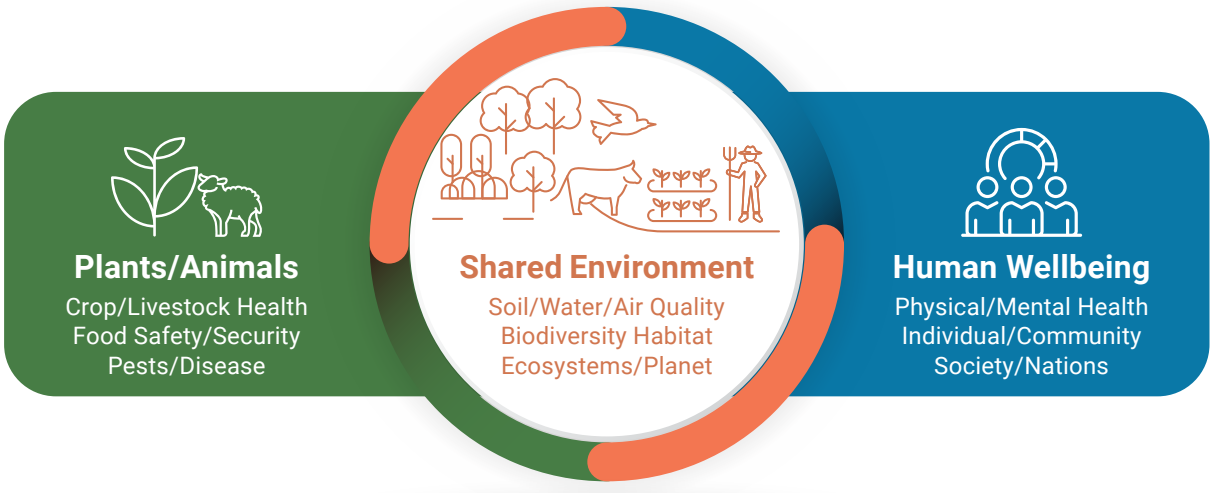
> "The health of soil, plants, animals, people, ecosystems, and the planetary processes is one and indivisible." [282]

Zoonotic Diseases

Humanity is now beginning to fully understand the existential threat posed by zoonotic diseases. Human-induced land use change and the wildlife trade are recognized as the major drivers of zoonotic pathogen spillover from wildlife to human populations, as is likely the case with COVID-19.[285] [286] Other such diseases have threatened humanity in recent years, including bird flu, swine flu, SARS, Ebola, and HIV.[287] While COVID-19 is a virus, zoonoses may also be caused by bacteria, fungi, or parasites which originate in wildlife, sometimes with domesticated animals as intermediate hosts.[288] Zoonotic diseases are generally transmitted through the air, close contact, by insects, or via contaminated food or water.

Neglected zoonotic diseases, such as anthrax, brucellosis, trypanosomiasis, or rabies, are endemic in affected populations (generally poor rural communities in the global South), yet receive significantly less attention and funding than emerging, highly transmittable diseases.[289]

FIGURE 1.15 One Health linkages



Wildlife Trade

Reducing or eliminating the wildlife trade will have many advantages for human health. The immediate source of COVID-19 is thought to have come from the sale of wild animals in so-called wet markets – most of which are illegal.[290] Shutting down this trade will require concerted efforts to enforce bans, disrupt supply chains, close risky markets, and most importantly reduce consumer demand for wildlife products.[291] This includes enforcement at the point of sale as well as the curtailment of illegal or unregulated hunting and wildlife farms. At the same time, additional efforts may be needed to compensate for the potential harmful impacts of bans and increased regulation on the livelihoods and food security of the rural poor dependent on this trade.[292]

Habitat Destruction

Trade agreements, corporate contracts, and certification schemes can help promote deforestation- and conversion-free supply chains and markets for commodities, such as coffee, cocoa, palm oil, soy, or timber.[293] To a large extent, the global trade in wildlife products has been enabled by roads and infrastructure development servicing commodity production and resource extraction in natural forests. In some regions, deforestation and land degradation resulting from charcoal production is a significant factor, with demand expected to increase further.[294] The destruction of biodiversity habitat directly impacts human health through increased exposure to zoonotic disease and the loss of ecosystem services.

Industrial Animal Agriculture

Modifications to intensive livestock production practices can help curb the emergence and spread of zoonotic disease and other health risks. Industrial animal agriculture, including wildlife farms, and the processing of meat, dairy, and other by-products, can be a conduit for the transmission of zoonotic diseases, including recent swine and avian flu outbreaks.[295] Factory farming typically involves administering growth hormones and antibiotics to animals, contributing to antimicrobial resistance and other human health risks.[296] [297] Crowded, unsanitary conditions and a narrow genetic base in commercial livestock operations make it easy for infection and disease to spread rapidly, even with the strictest biosecurity measures.

Balanced Diets

A healthy and balanced diet contributes to all facets of human development, protects against malnutrition, and promotes a strong immune system. The current overconsumption of meat, dairy, and junk food in high-income countries and communities is bad for both human and environmental health. Evidence suggests that a shift towards plant-based, whole food diets is healthier and more sustainable.[298] Globally, the land and carbon footprint of industrial animal products and ultra-processed foods is growing rapidly. Livestock takes up nearly 80% of global agricultural land yet produces less than 20% of the world's supply of calories.[299] Governments can reformulate dietary guidelines and eliminate subsidies for intensive animal agriculture and ultra-processed foods; businesses can invest in and market meat-free alternatives; and consumers can demand plant-based, whole foods in schools, workplaces, and restaurants.[300]

Pollution

Efforts to reduce soil, water, and air pollution from land use will improve human and environmental health outcomes. Pollution is the largest environmental cause of disease and death in the world today, primarily from water and soil contamination, exposure to chemicals, and improper waste management.[301] In agricultural areas, runoff from pesticides, fertilizers, and manure degrades water and soil quality, and causes eutrophication.[302] Sand and dust storms exacerbated by land degradation and climate change expose humans to airborne particulate matter containing harmful microorganisms and chemicals.[303]

1.4.3 DISASTER RISK REDUCTION

Population growth and settlement expansion mean that humanity increasingly needs to prepare for disasters. The planet is subject to a wide range of natural disasters, which may be transient, sudden, and unpredictable (tsunamis) or slow onset and long-lasting (drought, sea level rise). The causes of disasters are:

- biological (pests, diseases)
- environmental (land degradation, biodiversity loss, climate change)
- geological (earthquakes, volcanic eruptions)
- hydrometeorological (sand and dust storms, drought, floods, wildfires)
- technological (industrial pollution, accidents)

Understanding the causes of disaster is the first step to reducing risk. The risk of disaster is a combination of a hazard (biophysical phenomena) that has exposure (communities, assets) leading to vulnerability (loss and damage).[304] Wide-scale human catastrophes as a result of disasters typically involve the loss of life and property, famine, displacement, and conflict – all of which make recovery more difficult. The poor tend to be disproportionately affected, often residing in areas with the highest exposure, but also with fewer reserves to help them cope when disaster strikes.

At no other point in modern history has humankind faced such an array of familiar and unfamiliar risks and hazards, interacting in a hyper-connected and rapidly changing world.[305]

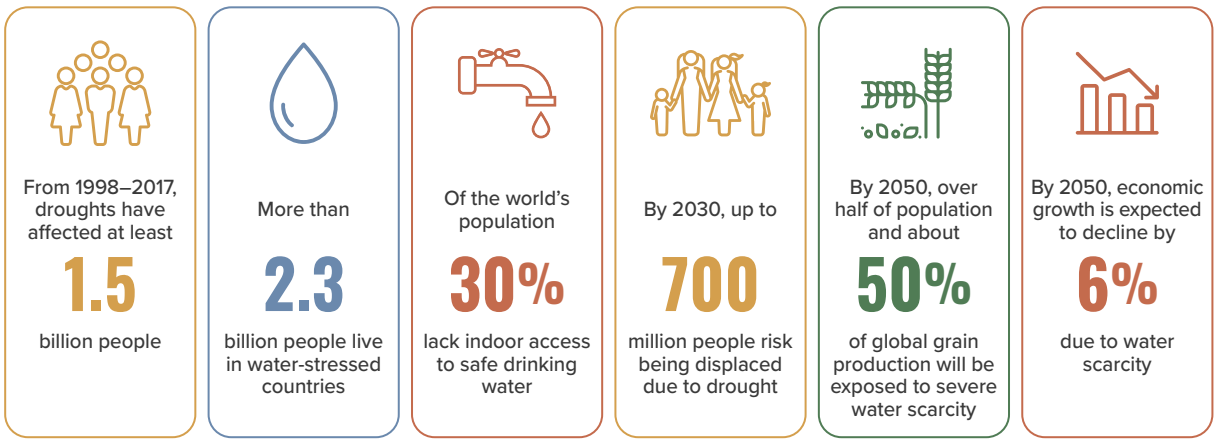
Drought, fires, heat waves, and pest invasions take a heavy toll on forests, with tropical forests increasingly exposed to human-induced fires.[306] In temperate regions, some forests are adapted to fire, which is essential for the regeneration of some species. The confluence of drought, heat, and fire is increasing stress on intact ecosystems and devastating those already degraded. Land restoration is most challenging after a catastrophic event that has caused significant disturbance in ecological processes and food webs.

Land restoration is an important tool for disaster risk reduction, but more importantly for preparedness. As with climate change, land degradation is often both a cause and a consequence of disasters. For example, desertification and drought are often exacerbated by human activities such as water management, while wildfires and pest invasions after drought can spread quickly and have massive impacts on ecosystem health. Floods and landslides are often triggered by urbanization, deforestation, and cultivation on sloping lands, which reduce ecosystems' capacity to regulate water.

Drought and Water Scarcity

More than 2.3 billion people currently reside in water-stressed countries. Between 1998 and 2017, droughts directly affected at least 1.5 billion people;[307] by 2030, up to 700 million could be displaced by drought.[308] By 2050, over half of the world's population and half of global grain production will be exposed to severe water scarcity.[309] [310]

FIGURE 1.16 Impacts of drought and water scarcity



Understanding the reasons for water stress and scarcity is critical to managing it effectively. Droughts occur when periods of abnormally dry conditions result in an acute deficit in freshwater availability. They are a recurring natural feature, intensified by human disturbance and, due to climate change, have become more frequent, intense, and wide ranging. The longer-term issue of water scarcity occurs when supplies and access to freshwater cannot meet the demands of humans and ecosystems. These water challenges require proactive land management, preparedness measures, and long-term planning to reduce the risks and impacts.

Integrated land and water management practices have proven effective in reducing risk and improving drought resilience. Techniques that use water more efficiently can lessen the damage inflicted by drought, increase soil productivity, and make farming less risky. While national governments are central to the effective governance of water resources, communities and individuals in drought-prone areas can utilize their knowledge of water conservation and harvesting to mitigate impacts. In the wider landscape, collaborative water resource planning and management can help manage trade-offs and reduce inequalities in access to water for agriculture, industrial, and domestic uses.[311]

Community-based water conservation initiatives are particularly important to women farmers and other vulnerable people who lack the capacity to respond effectively to drought and water scarcity.

Floods

Changes in rainfall intensity and the growing extent of land degradation amplify the risks of catastrophic floods.[312] Over 2 billion people in low- and middle-income countries live in areas at risk of inundation during a once-in-100-year flood event – of those, an estimated 132 million live in both extreme poverty and flood prone areas.[313] They are the first to suffer from contaminated water resources and disease outbreaks. Due in large part to their rapid onset, floods tend to result in higher asset and livelihood losses than other disasters. Restoring natural ecosystems and their infrastructure is a cost-effective means to address soil erosion, habitat loss, and water quality while engaging communities in activities to reduce flood risks, such as:

- restoring degraded rivers and wetlands in and around urban areas
- rehabilitating forests and grasslands in watersheds, on mountains and slopes
- protecting floodplains or developing them using natural infrastructure
- diversifying farming systems to manage soil and biodiversity for flood resilience[314]

Wildfires

The global risk, frequency, and impact of wildfires are rising due to climate change and poor land management practices, creating a feedback loop with increased emissions and ecosystem destruction.[315] [316] Wildfires can be triggered by lightning and other natural causes; however, the majority are started by humans either accidentally or deliberately. Wildfires are an ancient and essential feature of the environment that has shaped the evolution of plants, animals, and bio-geochemical processes. Periodic or controlled burning in some fire-adapted ecosystems is important for seed germination and to rejuvenate native flora.

Wildfires have both local and global effects and are a major source of air pollution that seasonally afflicts large population centers around the world. Pollutants of major public health concern during wildfire events are carbon monoxide, ozone, and particulate matter. They affect human physical and mental health and are associated with increased morbidity and mortality.[317] Wildfires also kill or displace wildlife, destroy their habitat, and diminish the provision of ecosystem services. They can expose soil, hastening erosion and desertification while encouraging the growth of fast-growing weeds that are even more prone to fire.[318]

Desertification

Desertification is defined as land degradation in arid, semi-arid, and dry sub-humid areas that occurs due to climatic variations and human activities.[319] While grasslands, forests, and croplands on the margins of deserts and barren land have a higher risk of desertification, it is still regarded as a complex, large-scale, all-encompassing, and long-term global hazard.[320] The primary human drivers of desertification, coupled with climate change, are the expansion of crop and grazing lands, and the over-exploitation of soil and water resources.[321]

Desertification is projected to increase across the world due to climate change while at the same time accelerating global warming through increased emissions. Associated risks include decreases in food production, the loss of biodiversity above and below ground, and encroachment by invasive plant species. In combination, these factors tend to increase poverty and reduce resilience in affected dryland communities, resulting in food and water insecurity, a higher disease burden, and

potentially increased resource conflicts and forced migration. Land restoration and sustainable crop and rangeland management, traditional or agroecological practices, are often the most cost-effective methods for halting or even reversing desertification trends.

Sand and Dust Storms

Sand and dust storms have increased dramatically in recent years and are aggravated by climate change, drought, and desertification. They present a range of hazards to human health and the environment, directly affecting dryland communities as well as more distant areas.[322] High winds pick up dust and chemical particles from exposed soil surfaces in source areas, which then can be transported for thousands of kilometers. Because of the transboundary nature and wide-ranging impacts of sand and dust storms, global and regional policy responses are needed, especially for early warning, monitoring, and source mitigation.

In 2019, the United Nations launched the Coalition on Combatting Sand and Dust Storms to catalyze global and regional actions to reduce their impacts on human health, food production, and the environment.

Sand and dust storms typically do not result in the same damage to infrastructure associated with other disasters, but the cumulative effects can be significant.[323] They damage crops, kill livestock, and strip topsoil, harming food production and local livelihoods. Atmospheric dust, especially when combined with industrial pollution, can cause or worsen human health problems, such as respiratory ailments and cardiovascular disease. Poor visibility results in traffic accidents and disrupts transport and supply chains.[324] Land restoration, using simple agronomic measures and grazing practices that protect soils, can significantly reduce the extent of source areas and limit the damage caused by sand and dust storms.[325]

Preparing for the Future

Climate change and expansion of human settlements will continue to increase the risk of and exposure to more frequent disasters worldwide. Mutually reinforcing feedback loops linked to global warming and shifting weather patterns are compounding multiple disasters in new synergistic ways.[326] After disaster strikes, it is tempting to rebuild quickly so people can recover their homes and livelihoods. However, it is critical to identify and change the land and water management practices that increase hazard exposure in the first place. For many communities and ecosystems alike, local actions to conserve, sustainably manage, and restore land resources is a cost-effective preparedness strategy to reduce vulnerabilities and increase the ability to cope and recover more quickly.[327] [328]

© Fiston Wasanga_CIFOR

ENDNOTES

1 Rockström, J., Beringer, T., Hole, D., Griscom, B., Mascia, M.B., Folke, C. and Creutzig, F., 2021. Opinion: We need biosphere stewardship that protects carbon sinks and builds resilience. Proceedings of the National Academy of Sciences, 118(38). https://doi.org/10.1073/pnas.2115218118

2 UNCCD, 2017. The Global Land Outlook, first edition, United Nations Convention to Combat Desertification, Bonn. https://knowledge.unccd.int/glo/GLO_first_edition

3 Bradshaw, C.J., Ehrlich, P.R., Beattie, A., Ceballos, G., Crist, E., Diamond, J., Dirzo, R., Ehrlich, A.H., Harte, J., Harte, M.E. and Pyke, G., 2021. Underestimating the challenges of avoiding a ghastly future. Frontiers in Conservation Science, 1, p.9. https://doi.org/10.3389/fcosc.2020.615419

4 IPBES, 2018. The IPBES assessment report on land degradation and restoration. Montanarella, L., Scholes, R., and Brainich, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn. https://ipbes.net/assessment-reports/ldr

5 IPCC, 2019. Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/srccl

6 IPCC, 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/sixth-assessment-report-working-group-i

7 IPBES, 2018. The IPBES assessment report on land degradation and restoration. Montanarella, L., Scholes, R., and Brainich, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn. 744 pp. https://ipbes.net/assessment-reports/ldr

8 UN ECOSOC, 2019. Special Edition of the Sustainable Development Goals Progress Report, Report of the Secretary-General, Supplementary Information. Economic and Social Commission, New York. https://unstats.un.org/sdgs/files/report/2019/secretary-general-sdg-report-2019--Statistical-Annex.pdf

9 UNCCD, 2018. Committee for the Review of the Implementation of the Convention: Preliminary analysis – strategic objective 1: To improve the condition of affected ecosystems, combat desertification/land degradation, promote sustainable land management and contribute to land degradation neutrality, ICCD/CRIC(17)/2. https://www.unccd.int/official-documentscric-17-georgetown-guyana-2019/iccdcric172

10 Smith, P., Calvin, K., Nkem, J., Campbell, D., Cherubini, F., Grassi, G., Korotkov, V., Le Hoang, A., Lwasa, S., McElwee, P. and Nkonya, E., 2020. Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification? Global change biology, 26(3), pp.1532-1575. https://doi.org/10.1111/gcb.14878

11 ISC, 2021. Unleashing Science: Delivering Missions for Sustainability. International Science Council, Paris. https://council.science/current/news/unleashing-science

12 IPCC, 2022. AR6 Climate Change 2022: Impacts, Adaptation, and Vulnerability. Working Group II Sixth Assessment Report. IPCC https://www.ipcc.ch/report/ar6/wg2

13 WWF, 2020. Living Planet Report 2020 - Bending the curve of biodiversity loss. Almond, R.E.A., Grooten M. and Petersen, T. (Eds). WWF, Gland, Switzerland. https://livingplanet.panda.org

14 Hertel, T.W., West, T.A., Börner, J. and Villoria, N.B., 2019. A review of global-local-global linkages in economic land-use/cover change models. Environmental Research Letters, 14(5), p.053003. https://doi.org/10.1088/1748-9326/ab0d33

15 Dasgupta, P., 2021. The Economics of Biodiversity: The Dasgupta Review. London: HM Treasury. https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

16 Ellis, E.C., Pascual, U. and Mertz, O., 2019. Ecosystem services and nature's contribution to people: negotiating diverse values and trade-offs in land systems. Current Opinion in Environmental Sustainability, 38, pp.86-94. https://doi.org/10.1016/j.cosust.2019.05.001

17 Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin III, F.S., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J. and Nykvist, B., De Wit C. A., Hughes T., van der Leeuw S., Rodhe H., Sorlin S., Snyder P. K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R. W., Fabry V. J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., and Foley J., 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32. http://www.ecologyandsociety.org/vol14/iss2/art32

18 UNEP, 2021. Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate. United Nations Environment Programme Nairobi. https://www.unep.org/resources/ecosystem-restoration-people-nature-climate

19 Willetts, E., Grant, L., Bansard, J., Kohler, P. M., Rosen, T., Bettelli, P., and Schröder, M., 2022. Health in the global environmental agenda: A policy guide. International Institute for Sustainable Development. https://www.iisd.org/publications/health-global-environment-agenda-policy-guide

20 Ding, H. et al., 2017. Roots of Prosperity: The economics and finance of restoring land. Washington, DC: World Resources Institute. https://www.wri.org/research/roots-prosperity-economics-and-finance-restoring-land

21 UNEP, 2021. Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate. United Nations Environment Programme, Nairobi. https://www.unep.org/resources/ecosystem-restoration-people-nature-climate

22 Ding, H. et al., 2017. Roots of Prosperity: The economics and finance of restoring land. Washington, DC: World Resources Institute. https://www.wri.org/research/roots-prosperity-economics-and-finance-restoring-land

23 OECD, 2019. Agricultural Policy Monitoring and Evaluation 2019. OECD Publishing, Paris. https://doi.org/10.1787/39bfe6f3-en

24 https://www.futuredirections.org.au/publication/from-system-shock-to-system-change-regenerative-opportunities

25 Ritchie H., and Roser M., 2020. Environmental Impacts of Food Production. OurWorldInData.org. https://ourworldindata.org/environmental-impacts-of-food

26 Mbow, C., Rosenzweig C., Barioni L.G., Benton T.G., Herrero M., Krishnapillai M., Liwenga E., Pradhan P., Rivera-Ferre M.G., Sapkota T., Tubiello F.N., and Xu Y., 2019. Food Security. In: IPCC, 2019. Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, Chapter 5. https://www.ipcc.ch/srccl/chapter/chapter-5

27 UN, 2020. UN Secretary-General's address at Columbia University: "The State of the Planet", António Guterres speech. UN (02 December). https://www.un.org/sg/en/content/sg/speeches/2020-12-02/address-columbia-university-the-state-of-the-planet

28 Sansoucy R., 1997. Livestock - a driving force for food security and sustainable development, FAO, Rome. http://www.fao.org/3/v8180t/v8180T07.htm

29 FAO, UNDP, and UNEP, 2021. A multi-billion-dollar opportunity – Repurposing agricultural support to transform food systems. FAO, Rome. https://doi.org/10.4060/cb6562en

30 Benton T.G., Bieg C., Harwatt H., Pudasaini R., and Wellesley L., 2021. Food system impacts on biodiversity loss. Three levers for food system transformation in support of nature. Research Paper. Energy, Environment and Resources Programme. Chatham House. https://www.chathamhouse.org/2021/02/food-system-impacts-biodiversity-loss

31 UN Food Systems Summit, 2021. Secretary-General's Chair Summary and Statement of Action on the UN Food Systems Summit. UN (23 September). https://www.un.org/en/food-systems-summit/news/making-food-systems-work-people-planet-and-prosperity

32 The Federal Ministry of Food and Agriculture Germany, 2022. Global Forum for Food and Agriculture, 14th Berlin Agriculture Ministers' Conference Final Communique. Sustainable Land Use: Food Security Starts with Soil. BMEL, Berlin. https://www.bmel.de/EN/topics/international-affairs/global-forum-for-food-and-agriculture/gffa2022-en.html

33 Barrios, E., Gemmill-Herren, B., Bicksler, A., Siliprandi, E., Brathwaite, R., Moller, S., Batello, C. and Tittonell, P., 2020. The 10 Elements of Agroecology: enabling transitions towards sustainable agriculture and food systems through visual narratives. Ecosystems and People, 16(1), pp.230-247. https://doi.org/10.1080/26395916.2020.1808705

34 Badgley, C. and Perfecto, I., 2007. Can organic agriculture feed the world? Renewable Agriculture and Food Systems, 22(2), pp.80-86. https://doi.org/10.1017/S1742170507001986

35 De Schutter, O. and Vanloqueren, G., 2011. The new green revolution: how twenty-first-century science can feed the world. Solutions, 2(4), pp.33-44. https://www.academia.edu/907244/The_New_Green_Revolution_How_Twenty-First-Century_Science_Can_Feed_the_World

36 The World Bank, 2021. Employment in agriculture (% of total employment), ILOSTAT Database. World Bank (29 January). https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS

37 Lowder, S.K., Skoet, J. and Raney, T., 2016. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. World Development, 87, pp.16-29. https://doi.org/10.1016/j.worlddev.2015.10.041

38 Anseeuw W., and Baldinelli G.M., 2020. Uneven Ground: Land inequality at the hearth of unequal societies. International Land Coalition and Oxfam. https://www.landcoalition.org/en/uneven-ground/

39 Tamburini, G., Bommarco, R., Wanger, T.C., Kremen, C., van der Heijden, M.G., Liebman, M. and Hallin, S., 2020. Agricultural diversification promotes multiple ecosystem services without compromising yield. Science advances, 6(45), p.eaba1715. https://doi.org/10.1126/sciadv.aba1715

40 Ricciardi, V., Mehrabi, Z., Wittman, H., James, D. and Ramankutty, N., 2021. Higher yields and more biodiversity on smaller farms. Nature Sustainability, pp.1-7. https://doi.org/10.1038/s41893-021-00699-2

41 Lal, R., 2015. Restoring soil quality to mitigate soil degradation. Sustainability 7(5):5875-5895. https://doi.org/10.3390/su7055875

42 Altieri, M.A., 1995. Agroecology: the science of sustainable agriculture, 2nd ed. CRC Press. https://regabrasil.files.wordpress.com/2018/10/agroecology-the-science-of-sustainable-agriculture-altieri.pdf

43 Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K. and Johns, C., 2020. What is regenerative agriculture? A review of scholar and practitioner definitions based on processes and outcomes. Frontiers in Sustainable Food Systems, 4, p.194. https://doi.org/10.3389/fsufs.2020.577723

44 Lowder, S.K., Sánchez, M.V. and Bertini, R., 2021. Which farms feed the world and has farmland become more concentrated? World Development, 142, p.105455. https://doi.org/10.1016/j.worlddev.2021.105455

45 Pretty, J., Benton, T.G., Bharucha, Z.P., Dicks, L.V., Flora, C.B., Godfray, H.C.J., Goulson, D., Hartley, S., Lampkin, N., Morris, C. and Pierzynski, G., 2018. Global assessment of agricultural system redesign for sustainable intensification. Nature Sustainability, 1(8), pp.441-446. https://doi.org/10.1038/s41893-018-0114-0

46 High-Level Panel on Water, 2018. Making every drop count- An agenda for water action. UN DESA, New York. https://sustainabledevelopment.un.org/content/documents/17825HLPW_Outcome.pdf

47 Weinzettel, J., Hertwich, E.D., Peters, G.P., Kjartan, S-O. and Galli, A., 2013. Affluence drives global displacement of land use. Global Environmental Change, 23(2). https://doi.org/10.1016/j.gloenvcha.2012.12.010

48 Yu, Y., Feng, K. and Hubacek, K., 2013. Tele-connecting local consumption to global land use. Global Environmental Change, 50, 190-200. https://doi.org/10.1016/j.gloenvcha.2013.04.006

49 Chotte, J-L. and Orr, B.J., 2021. Mitigating "displaced" land degradation and the risk of spillover through the decommoditization of land products. Land Use Policy 109:105659. https://doi.org/10.1016/j.landusepol.2021.105659

50 Lucas, P., Maas, T. and Kok, M., 2020. Insights from global environmental assessments Lessons for the Netherlands. The Hague, PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/sites/default/files/downloads/pbl-2020-insights-from-global-environmental-assessments-3490.pdf

51 Hertel, T.W., West, T. A.P., Börner, J. and Villoria, N.B., 2019. A review of global-local-global linkages in economic land-use/cover change models, Environmental Research Letters, 14(8). https://doi.org/10.1088/1748-9326/ab0d33

52 OECD and FAO, 2018. OECD-FAO Agricultural Outlook 2018-2027. OECD Publishing, Paris and FAO, Rome. https://doi.org/10.1787/agr_outlook-2018-en

53 Borras Jr, S.M., Mills, E.N., Seufert, P., Backes, S., Fyfe, D., Herre, R. and Michéle, L., 2020. Transnational land investment web: land grabs, TNCs, and the challenge of global governance. Globalizations, 17(4), pp.608-628. https://doi.org/10.1080/14747731.2019.1669384

54 Committee on World Food Security, 2021. Global Strategic Framework for Food Security & Nutrition. FAO, Rome. http://www.fao.org/cfs/policy-products/onlinegsf

55 Lowder, S.K., Sánchez, M.V. and Bertini, R., 2021. Which farms feed the world and has farmland become more concentrated? World Development, 142, p.105455. https://doi.org/10.1016/j.worlddev.2021.105455

56 OECD, 2019. Agricultural Policy Monitoring and Evaluation 2019. OECD Publishing, Paris. https://doi.org/10.1787/39bfe6f3-en https://www.oecd-ilibrary.org/agriculture-and-food/agricultural-policy-monitoring-and-evaluation-2019_39bfe6f3-en

57 IPCC, 1990. Climate change: The IPCC scientific assessment. Cambridge University Press. https://archive.ipcc.ch/publications_and_data/publications_ipcc_first_assessment_1990_wg1.shtml

58 UNFCCC, 2022. The Paris Agreement. UNFCCC, Bonn. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

59 Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P. and Woodbury, P., 2017. Natural climate solutions. Proceedings of the National Academy of Sciences, 114(44), pp.11645-11650. https://doi.org/10.1073/pnas.1710465114

60 IPCC, 2018. IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. (Masson-Delmotte, V. et al. (eds.)). https://www.ipcc.ch/sr15

61 IPCC, 2018. IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. (Masson-Delmotte, V. et al (eds.)). https://www.ipcc.ch/sr15

62 Lynch, J., Cain, M., Frame, D. and Pierrehumbert, R., 2021. Agriculture's contribution to climate change and role in mitigation is distinct from predominantly fossil CO2-emitting sectors. Frontiers in sustainable food systems, 4, p.300. https://doi.org/10.3389/fsufs.2020.518039

63 Smith P., Bustamante M., Ahammad H., Clark H., Dong H., Elsiddig E.A., Haberl H., Harper R., House J., Jafari M., Masera O., Mbow C., Ravindranath N.H., Rice C.W., Robledo Abad C., Romanovskaya A., Sperling F., and Tubiello F., 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: IPCC, 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O. et al.(eds.)]. Chapter 11. Cambridge University Press. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter11.pdf

64 Steiner, J.L., and Fortuna, A., 2020. Climate change, greenhouse gas emissions, and carbon sequestration: Challenges and solutions for natural resources conservation through time. In: Delgado, J., Gantzer, C., Sasssenrath, G., (eds). Soil and Water Conservation: A Celebration of 75 Years. Journal of Soil and Water Conservation Society. p. 229-240. https://www.researchgate.net/publication/353804316_Steiner_JL_and_Fortuna_AM_2020_Climate_Change_Greenhouse_Gas_Emissions_and_Carbon_Sequestration_Challenges_and_Solutions_for_Natural_Resources_Conservation_through_Time_Soil_and_Water_Conservation_A_C

65 IPCC, 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V. et al. (eds.)]. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1

66 IPCC, 2018. IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. (Masson-Delmotte, V. et al (eds.)). https://www.ipcc.ch/sr15

67 Patz, J.A., Daszak, P., Tabor, G.M., Aguirre, A.A., Pearl, M., Epstein, J., Wolfe, N.D., Kilpatrick, A.M., Foufopoulos, J., Molyneux, D. and Bradley, D.J., 2004. Unhealthy landscapes: policy recommendations on land use change and infectious disease emergence. Environmental health perspectives, 112(10), pp.1092-1098. https://doi.org/10.1289/ehp.6877

68 Ray, D.K., West, P.C., Clark, M., Gerber, J.S., Prishchepov, A.V. and Chatterjee, S., 2019. Climate change has likely already affected global food production. PloS one, 14(5), p.e0217148. https://doi.org/10.1371/journal.pone.0217148

69 European Environment Agency, 2017. Climate change, impacts and vulnerability in Europe 2016: An indicator-based report. EEA Report No 1/2017. Copenhagen. https://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016

70 Turetsky, M.R., Abbott, B.W., Jones, M.C., Anthony, K.W., Olefeldt, D., Schuur, E.A., Koven, C., McGuire, A.D., Grosse, G., Kuhry, P. and Hugelius, G., 2019. Permafrost collapse is accelerating carbon release. Nature Comment, 32-34. https://doi.org/10.1038/d41586-019-01313-4

71 Kopittke, P.M., Menzies, N.W., Wang, P., McKenna, B.A. and Lombi, E., 2019. Soil and the intensification of agriculture for global food security. Environment international, 132, p.105078. https://doi.org/10.1016/j.envint.2019.105078

72 Amelung, W., Bossio, D., de Vries, W., Kögel-Knabner, I., Lehmann, J., Amundson, R., Bol, R., Collins, C., Lal, R., Leifeld, J. and Minasny, B., 2020. Towards a global-scale soil climate mitigation strategy. Nature Communications, 11(1), pp.1-10. https://doi.org/10.1038/s41467-020-18887-7

73 FAO, 2018. FAO Statistical Databases.

74 Sanderman, J., Hengl, T. and Fiske, G.J., 2017. Soil carbon debt of 12,000 years of human land use. Proceedings of the National Academy of Sciences, 114(36), pp.9575-9580. https://doi.org/10.1073/pnas.1706103114

75 Bossio, D.A., Cook-Patton, S.C., Ellis, P.W., Fargione, J., Sanderman, J., Smith, P., Wood, S., Zomer, R.J., Von Unger, M., Emmer, I.M. and Griscom, B.W., 2020. The role of soil carbon in natural climate solutions. Nature Sustainability, 3(5), pp.391-398. https://doi.org/10.1038/s41893-020-0491-z

76 Hong, C., Burney, J.A., Pongratz, J., Nabel, J.E., Mueller, N.D., Jackson, R.B. and Davis, S.J., 2021. Global and regional drivers of land-use emissions in 1961–2017. Nature, 589(7843), pp.554-561. https://doi.org/10.1038/s41586-020-03138-y

77 Joint Research Centre, Institute for Environment and Sustainability, 2016. CAPRESE-SOIL, CArbon PREservation and SEquestration in agricultural soils: options and implications for agricultural production, report of task 7: final report, Publications Office. https://data.europa.eu/doi/10.2788/77068

78 Elias, M., Joshi, D. and Meinzen-Dick, R., 2021. Restoration for Whom, by Whom? A Feminist Political Ecology of Restoration. Ecological Restoration, 39(1-2), pp.3-15. https://doi.org/10.3368/er.39.1-2.3

79 Prober, S.M., Williams, K.J., Broadhurst, L.M. and Doerr, V.A., 2017. Nature conservation and ecological restoration in a changing climate: what are we aiming for? The Rangeland Journal, 39(6), pp.477-486. https://doi.org/10.1071/RJ17069.

80 Furceri, D. and Pizzuto, P., 2021. Will Covid-19 affect inequality? Evidence from past pandemics. IMF Working Papers, 2021(127). https://www.imf.org/en/Publications/WP/Issues/2021/05/01/Will-COVID-19-Affect-Inequality-Evidence-from-Past-Pandemics-50286

81 Larson, A.M., Mausch, K., Bourne, M., Luttrell, C., Schoneveld, G., Cronkleton, P., Locatelli, B., Catacutan, D., Cerutti, P., Chomba, S. and Djoudi, H., 2021. Hot topics in governance for forests and trees: towards a (just) transformative research agenda. Forest Policy and Economics, 131, p.102567. https://doi.org/10.1016/j.forpol.2021.102567

82 de Vries, W.T., Bennett R.M. and Zevenbergen, J., 2015. Toward Responsible Land Administration. In Zevenbergen, J., De Vries, W. and Bennett, R. (Eds.) Advances in Responsible Land Administration, CRC Press, Taylor and Francis Group. https://doi.org/10.1201/b18988

83 Ellis, E.C. and Mehrabi, Z., 2019. Half Earth: promises, pitfalls, and prospects of dedicating Half of Earth's land to conservation. Current Opinion in Environmental Sustainability, 38, pp.22-30. https://doi.org/10.1016/j.cosust.2019.04.008

84 Hatab, A.A., Cavinto, M.E.R., Lindermeyer, A., and Lagerkvist, C-J., 2019. Urban sprawl, food security and agricultural systems in developing countries: A systematic review of the literature, Cities 94. https://doi.org/10.1016/j.cities.2019.06.001

85 United Nations, 1992. United Nations Conference on Environment & Development, Rio de Janeiro, Brazil, 3 to 14 June 1992: AGENDA 21. UNDESA DSDG. https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

86 Lowder, S.K., Sánchez, M.V. and Bertini, R., 2021. Which farms feed the world and has farmland become more concentrated? World Development, 142, p.105455. https://doi.org/10.1016/j.worlddev.2021.105455

87 Fan, S. and Rue, C., 2020. The Role of Smallholder Farms in a Changing World. In The Role of Smallholder Farms in Food and Nutrition Security (pp. 13-28). Springer, Cham. https://doi.org/10.1007/978-3-030-42148-9_2

88 International Food Policy Research Institute, 2005. The future of small farms: Proceedings of a research workshop, Wye, UK, June 26-29, 2005. IFPRI, Washington, DC. https://www.ifpri.org/publication/future-small-farms

89 Ricciardi, V., Mehrabi, Z., Wittman, H., James, D. and Ramankutty, N., 2021. Higher yields and more biodiversity on smaller farms. Nature Sustainability, pp.1-7. https://doi.org/10.1038/s41893-021-00699-2

90 Flintan F., 2020. 2020 #InspireChallenge winners. ILRI (21 October). https://www.ilri.org/news/rangelands-spotlight-cgiars-big-data-platform-inspire-challenge

91 IUCN, WWF, and UNCCD, 2020. Spotlight on rangelands, Background note for multi actor dialogue: "Advancing international action for rangeland restoration". IUCN, Gland. (16 November). https://www.iucn.org/sites/dev/files/content/documents/en_background_note_for_international_rangeland_dialogue_final.pdf

92 Herrera, P.M., Davies, J. and Baena, P.M., 2014. The Governance of Rangelands, Collective action for sustainable pastoralism, Earthscan from Routledge, London and New York. https://portals.iucn.org/library/node/44904

93 IFAD, 2018. Toolkit: Engaging with pastoralists – a holistic development approach. IFAD, Rome. https://www.ifad.org/en/web/knowledge/-/publication/toolkit-engaging-with-pastoralists-a-holistic-development-approach

94 Kenee, F.B., Tesfaye, G. and Teshome, J., 2020. Property rights and governance of land resources in pastoral areas of the Oromia region, Ethiopia. https://doi.org/10.1163/15718115-02704009

95 Katz, E., 2010. Land tenure, property rights, and natural resource management: land tenure and property rights reform in the developing world: who is vulnerable? Prepared for the United States Agency for International Development, USAID Contract Number EPP-00-06-00008-00, Property Rights and Resource Governance (PRRGP) Task Order under PLACE Indefinite Quantity Contract. USAID https://land-links.org/wp-content/uploads/2016/09/USAID_Land_Tenure_Vulnerable_Populations_Report.pdf

96 Basnett B.S., Elias M., Ihalainen M. and Paez Valencia A.M., 2017. Gender matters in Forest Landscape Restoration: A framework for design and evaluation. CIFOR and CGIAR. https://www.cifor.org/publications/pdf_files/brief/6685-brief.pdf

97 UN Women, Global Mechanism of the UNCCD, and IUCN, 2019. A manual for gender-responsive Land Degradation Neutrality transformative projects and programmes. UN Women, New York. https://www.unwomen.org/en/digital-library/publications/2019/09/manual-for-gender-responsive-land-degradation-neutrality-transformative-projects-and-programmes

98 Worsdell, T., Kumar, K., Allan, J.R., Gibbon, G.E.M., White, A., Khare, A. and Frechette, A., 2020. Rights-Based Conservation: The path to preserving Earth's biological and cultural diversity? Rights and Resources Institute Technical Report. https://doi.org/10.13140/RG.2.2.17198.95042

99 ILO, 2019. Implementing the ILO Indigenous and Tribal Peoples Convention No. 169: Towards an inclusive, sustainable and just future. ILO, Geneva. https://www.ilo.org/global/publications/books/WCMS_735607/lang--en/index.htm

100 Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C.J., Watson, J.E., Zander, K.K., Austin, B., Brondizio, E.S. and Collier, N.F., 2018. A spatial overview of the global importance of Indigenous lands for conservation. Nature Sustainability, 1(7), pp.369-374. https://doi.org/10.1038/s41893-018-0100-6

101 FAO, 2021. The White/Wiphala Paper on Indigenous Peoples' food systems. FAO, Rome. https://doi.org/10.4060/cb4932en

102 Domínguez, L. and Luoma, C., 2020. Decolonising conservation policy: How colonial land and conservation ideologies persist and perpetuate indigenous injustices at the expense of the environment. Land, 9(3), p.65. https://doi.org/10.3390/land9030065

103 Carter, S., Manceur, A.M., Seppelt, R. Hermans-Neuman, K., Herold, M., and Verchot, L., 2017. Large scale land acquisitions and REDD+: a synthesis of conflicts and opportunities. Environmental Research Letters, 12, 035010. https://doi.org/10.1088/1748-9326/aa6056

104 United Nations, 2018. World Youth Report: Youth and the 2030 Agenda for Sustainable Development. UN, New York. https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2018/12/WorldYouthReport-2030Agenda.pdf

105 Kaag M., Baltissen, G., Steel, G., and Lodder, A., 2020. Migration, youth and land in west Africa: Making the connections work for inclusive development, Land 8(4),60. https://doi.org/10.3390/land8040060

106 Kararach, G., Hanson, K.T. and Léautier, F.A., 2011. Regional integration policies to support job creation for Africa's burgeoning youth population. World Journal of Entrepreneurship, Management and Sustainable Development, Vol 7 No. 27374, pp-117-215. https://doi.org/10.1108/20425961201000035

107 UNHCR, 2021. Figures at a Glance. UNHCR, Geneva. https://www.unhcr.org/en-us/figures-at-a-glance.html

108 Internal Displacement Monitoring Centre, 2021. Global Report on Internal Displacement 2021 (GRID 2021): Internal displacement in a changing climate. IDMC, Geneva. https://www.internal-displacement.org/global-report/grid2021

109 Katz, E., 2010. Land tenure, property rights, and natural resource management: land tenure and property rights reform in the developing world: who is vulnerable? Prepared for the United States Agency for International Development, USAID Contract Number EPP-00-06-00008-00, Property Rights and Resource Governance (PRRGP) Task Order under PLACE Indefinite Quantity Contract. USAID https://land-links.org/wp-content/uploads/2016/09/USAID_Land_Tenure_Vulnerable_Populations_Report.pdf

110 Refugees International, 2020. COVID-19 and the Displaced: addressing the threat of the novel Coronavirus in humanitarian emergencies. Issue Brief, Report. Refugees International (30 March). https://www.refugeesinternational.org/reports/2020/3/29/covid-19-and-the-displaced-addressing-the-threat-of-the-novel-coronavirus-in-humanitarian-emergencies

111 Martin, A., Armijos, M.T., Coolsaet, B., Dawson, N., AS Edwards, G., Few, R., Gross-Camp, N., Rodriguez, I., Schroeder, H., GL Tebboth, M. and White, C.S., 2020. Environmental Justice and Transformations to Sustainability. Environment: Science and Policy for Sustainable Development, 62(6), pp.19-30. https://doi.org/10.1080/00139157.2020.1820294

112 Schlosberg, D., 2007. Defining environmental justice: Theories, movements, and nature. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199286294.003.0001

113 Sherriff, G. 2013. Environmental justice and food. Encyclopedia of Food and Agricultural Ethics. In: Thompson P., Kaplan D. (eds) Encyclopedia of Food and Agricultural Ethics. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-6167-4_262-3

114 Committee on World Food Security, 2012. Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. FAO, Rome. https://www.fao.org/tenure/voluntary-guidelines/en

115 Treves, A., Artelle, K.A., Darimont, C.T., Lynn, W.S., Paquet, P., Santiago-Ávila, F.J., Shaw, R. and Wood, M.C., 2018. Intergenerational equity can help to prevent climate change and extinction. Nature ecology & evolution, 2(2), pp.204-207. https://doi.org/10.1038/s41559-018-0465-y

116 Weiss Brown, E., 2021. Intergenerational equity. Max Planck Encyclopaedias of International Law. https://opil.ouplaw.com/view/10.1093/law:epil/9780199231690/law-9780199231690-e1421

117 Golub, A., Mahoney, M. and Harlow, J., 2013. Sustainability and intergenerational equity: do past injustices matter? Sustainability science, 8(2), pp.269-277. https://doi.org/10.1007/s11625-013-0201-0

118 United Nations Economic Commission for Latin America and the Caribbean, 2018. Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean. ECLAC, Santiago. https://repositorio.cepal.org/bitstream/handle/11362/43583/1/S1800428_en.pdf

119 McLain, R., Lawry, S., Guariguata, M. R., and Reed, J., 2021. Toward a tenure-responsive approach to forest landscape restoration: a proposed tenure diagnostic for assessing restoration opportunities. Land Use Policy 104: 103748. https://doi.org/10.1016/j.landusepol.2018.11.053

120 Tseng, T.W.J., Robinson, B.E., Bellemare, M.F., BenYishay, A., Blackman, A., Boucher, T., Childress, M., Holland, M.B., Kroeger, T., Linkow, B. and Diop, M., 2021. Influence of land tenure interventions on human well-being and environmental outcomes. Nature Sustainability, 4(3), pp.242-251. https://doi.org/10.1038/s41893-020-00648-5

121 FAO, (n.d.) Land governance. http://www.fao.org/land-water/land/land-governance/en

122 Palmer D., Fricska S., Wehrmann B., et al., 2009. Towards improved land governance. Land Tenure Working Paper 11. FAO and UN-Habitat. https://www.fao.org/3/ak999e/ak999e.pdf

123 Metternicht, G., 2018. Land use and spatial planning: Enabling sustainable management of land resources. Springer, Cham. https://link.springer.com/book/10.1007/978-3-319-71861-3

124 Bixler, R.P., Jedd, T. and Wyborn, C., 2018. Polycentric governance and forest landscape restoration: Considering local needs, knowledge types and democratic principles. In Forest landscape restoration: Integrated Approaches to Support Effective Implementation Routledge. Taylor and Francis. pp. 176-197. https://www.taylorfrancis.com/chapters/edit/10.4324/9781315111872-11/polycentric-governance-forest-landscape-restoration-patrick-bixler-theresa-jedd-carina-wyborn?context=ubx

125 Long, H., Liu, J., Tu, C. and Fu, Y., 2018. From state-controlled to polycentric governance in forest landscape restoration: the case of the Ecological Forest Purchase Program in Yong'an Municipality of China. Environmental management, 62(1), pp.58-69. https://doi.org/10.1007/s00267-017-0972-7

126 Erbaugh, J.T., Pradhan, N., Adams, J., Oldekop, J.A., Agrawal, A., Brockington, D., Pritchard, R. and Chhatre, A., 2020. Global forest restoration and the importance of prioritizing local communities. Nature Ecology & Evolution, 4(11), pp.1472-1476. https://doi.org/10.1038/s41559-020-01282-2

127 McSweeney, K. and Coomes, O.T., 2020. Who owns the Earth? A challenge for the land system science community. Journal of Land Use Science, 15(4), pp.482-488. https://doi.org/10.1080/1747423X.2020.1765428

128 de Jong, W., van der Zon, M., Urushima, A.F., Youn, Y.C., Liu, J. and Li, N., 2018. Tenure, property rights and forest landscape restoration. In Forest landscape restoration: Integrated Approaches to Support Effective Implementation (pp. 158-175).). Routledge. Taylor and Francis. pp. 158-175. https://www.taylorfrancis.com/books/e/9781315111872/chapters/10.4324/9781315111872-10

129 Wilson, S.J. and Cagalanan, D., 2016. Governing restoration: Strategies, adaptations and innovations for tomorrow's forest landscapes. World Development Perspectives, 4:11–15. https://doi.org/10.1016/j.wdp.2016.11.015

130 Committee on World Food Security, 2012. Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. FAO, Rome. https://www.fao.org/tenure/voluntary-guidelines/en

131 United Nations Human Settlements Programme, Institute of Rural Reconstruction, and Global Land Tool Network and International, 2012. Handling land, Innovative tools for land governance and secure tenure. UN Habitat, Nairobi. https://unhabitat.org/handling-land-innovative-tools-for-land-governance-and-secure-tenure

132 Chigbu, U.E. et al., 2021. Tenure-Responsive Land Use Planning: A practical guide for country -level intervention. A world I which everyone enjoys secure land rights. Report 5/2021. UN Habitat, Nairobi. https://unhabitat.org/tenure-responsive-land-use-planning-a-practical-guide-for-country-level-intervention

133 Chigbu, U.E., Schopf, A., de Vries, W.T., Masum, F., Mabikke, S., Antonio, D. and Espinoza, J., 2017. Combining land-use planning and tenure security: A tenure responsive land-use planning approach for developing countries. Journal of Environmental Planning and Management, 60(9), pp.1622-1639. https://doi.org/10.1080/09640568.2016.1245655

134 Platteau, J.P., 2000. Allocating and enforcing property rights in land: Informal versus formal mechanisms in sub-Saharan Africa. Nordic Journal of Political Economy, 26(1), pp.55-81. http://www.nopecjournal.org/NOPEC_2000_a03.pdf

135 McLain, R., Lawry, S., Guariguata, M. R., and Reed, J., 2021. Toward a tenure-responsive approach to forest landscape restoration: a proposed tenure diagnostic for assessing restoration opportunities. Land Use Policy 104: 103748. https://doi.org/10.1016/j.landusepol.2018.11.053

136 FAO, 2020. Strengthening civic spaces in spatial planning processes. Governance of Tenure Technical Guide No. 12. FAO, Rome. https://www.fao.org/documents/card/en/c/cb0422en

137 Chazdon, R.L., Wilson, S.J., Brondizio, E, Guariguata, M.R. and Herbohn, J., 2021. Key challenges for governing forest and landscape restoration across different contexts, Land Use Policy, 104. https://doi.org/10.1016/j.landusepol.2020.104854

138 Briassoulis, H., 2019. Combating Land Degradation and Desertification: The Land-Use Quandary, Land 8(2) pp. 27. https://doi.org/10.3390/land8020027

139 Karimi, A. and Adams, V.M., 2019. Planning for the future: combining spatially-explicit public preferences with tenure policies to support land-use planning. Land Use Policy, 82, pp.497-508. https://doi.org/10.1016/j.landusepol.2018.12.033

140 Chigbu, U.E., Alemayehu, Z. and Dachaga, W., 2019. Uncovering land tenure insecurities: Tips for tenure responsive land-use planning in Ethiopia. Development in Practice, 29(3), pp.371-383. https://doi.org/10.1080/09614524.2019.1567688

141 Chigbu, U.E., Ntihinyurwa, P.D., de Vries, W.T. and Ngenzi, E.I., 2019. Why tenure responsive land-use planning matters: Insights for land use consolidation for food security in Rwanda. International journal of environmental research and public health, 16(8), p.1354. https://doi.org/10.3390/ijerph16081354

142 Briassoulis, H., 2019. Combating land degradation and desertification: The land-use planning quandary. Land, 8(2), p.27. https://doi.org/10.3390/land8020027

143 OECD and FAO, 2019: OECD-FAO Agricultural Outlook 2020-2029. OECD Publishing, Paris and FAO, Rome. https://doi.org/10.1787/1112c23b-en

144 Stafford-Smith, M. and Metternicht, G., 2021. Governing drylands as global environmental commons. Current Opinion in Environmental Sustainability, 48, pp.115-124. https://doi.org/10.1016/j.cosust.2020.12.006

145 Halldórsson, G., Ágústsdóttir, A.M., Aradóttir, Á.L., Arnalds, Ó., Hagen, D., Mortensen, L., Nilsson, C., Óskarsson, H., Pagneux, E., Pilli-Sihvola, K. and Raulund-Rasmussen, K., 2017. Ecosystem Restoration for Mitigation of Natural Disasters. Nordic Council of Ministers. https://www.diva-portal.org/smash/get/diva2:1134363/FULLTEXT01.pdf

146 Huang, C.W., McDonald, R.I. and Seto, K.C., 2018. The importance of land governance for biodiversity conservation in an era of global urban expansion. Landscape and Urban Planning, 173, pp.44-50. https://doi.org/10.1016/j.landurbplan.2018.01.011

147 Ritchie H., Roser M., 2018. Urbanization. Our World in Data. https://ourworldindata.org/urbanization

148 Weeks, J.R., 2010. Defining urban areas. Defining Urban Areas. In T. Rashed, & C. Jurgens (Eds.), Remote Sensing of Urban and Suburban Areas, Remote Sensing and Digital Image Processing (Vol. 10, pp. 33-45). Springer, Dordrecht. https://ipc.sdsu.edu/wp-content/uploads/2019/03/Weeks_Ch3.pdf

149 Aronson, M.F., Lepczyk, C.A., Evans, K.L., Goddard, M.A., Lerman, S.B., MacIvor, J.S., Nilon, C.H. and Vargo, T., 2017. Biodiversity in the city: key challenges for urban green space management. Frontiers in Ecology and the Environment, 15(4), pp.189-196. https://doi.org/10.1002/fee.1480

150 Snep, R.P. and Clergeau, P., 2020. Biodiversity in cities, reconnecting humans with nature. Sustainable built environments, pp.251-274. https://link.springer.com/referenceworkentry/10.1007/978-1-0716-0684-1_296?noAccess=true

151 Quaranta, E., Dorati, C. and Pistocchi, A., 2021. Water, energy and climate benefits of urban greening throughout Europe under different climatic scenarios. Scientific reports, 11(1), pp.1-10. https://doi.org/10.1038/s41598-021-88141-7

152 Elmqvist, T., Setälä, H., Handel, S.N., Van Der Ploeg, S., Aronson, J., Blignaut, J.N., Gomez-Baggethun, E., Nowak, D.J., Kronenberg, J. and De Groot, R., 2015. Benefits of restoring ecosystem services in urban areas. Current opinion in environmental sustainability, 14, pp.101-108. https://doi.org/10.1016/j.cosust.2015.05.001

153 Brown, K. and Mijic, A., 2019. Integrating green and blue spaces into our cities: Making it happen. Grantham Institute, (30), pp.1-10. Imperial College, London. https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Integrating-green-and-blue-spaces-into-our-cities--Making-it-happen-.pdf

154 UNEP and UNDP, 2021. Smart, Sustainable and Resilient cities: the Power of Nature-based Solutions. A Working Paper for the G20. UNEP, Nairobi. https://www.unep.org/resources/report/smart-sustainable-and-resilient-cities-power-nature-based-solutions

155 Ingram, M., 2008. Urban ecological restoration. Ecological restoration, 26(3), pp.175-177. https://doi.org/10.3368/er.26.3.175

156 Clinton, N., Stuhlmacher, M., Miles, A., Uludere Aragon, N., Wagner, M., Georgescu, M., Herwig, C. and Gong, P., 2018. A global geospatial ecosystem services estimate of urban agriculture. Earth's Future, 6(1), pp.40-60. https://doi.org/10.1002/2017EF000536

157 Artmann, M. and Sartison, K., 2018. The role of urban agriculture as a nature-based solution: A review for developing a systemic assessment framework. Sustainability, 10(6), p.1937. https://doi.org/10.3390/su10061937

158 Mills, J.G., Bissett, A., Gellie, N.J., Lowe, A.J., Selway, C.A., Thomas, T., Weinstein, P., Weyrich, L.S. and Breed, M.F., 2020. Revegetation of urban green space rewilds soil microbiotas with implications for human health and urban design. Restoration Ecology, 28, pp. S322-S334. https://doi.org/10.1111/rec.13175

159 Norton, B.A., Evans, K.L. and Warren, P.H., 2016. Urban biodiversity and landscape ecology: patterns, processes and planning. Current Landscape Ecology Reports, 1(4), pp.178-192. https://doi.org/10.1007/s40823-016-0018-5

160 da Cruz, N.F., Rode, P. and McQuarrie, M., 2019. New urban governance: A review of current themes and future priorities. Journal of Urban Affairs, 41(1), pp.1-19. https://doi.org/10.1080/07352166.2018.1499416

161 Gross, M. and Hoffmann-Riem, H., 2005. Ecological restoration as a real-world experiment: designing robust implementation strategies in an urban environment. Public Understanding of Science, 14(3), pp.269-284. https://doi.org/10.1177/0963662505050791

162 Adebisi, A. and Monisola, T.A., 2012. Motivations for women involvement in urban agriculture in Nigeria. Asian Journal of Agriculture and Rural Development, 2(393-2016-23833), pp.327-343. https://ageconsearch.umn.edu/record/197979/files/4-101-AJARD-337-343.pdf

163 UNFPA, 2017. State of world population 2007: Unleashing the Potential of Urban Growth. UNFPA, New York. https://www.unfpa.org/publications/state-world-population-2007

164 López-Goyburu, P. and García-Montero, L.G., 2018. The urban-rural interface as an area with characteristics of its own in urban planning: A review. Sustainable cities and society, 43, pp.157-165. https://doi.org/10.1016/j.scs.2018.07.010

165 UN-Habitat, 2019. Urban-Rural Linkages: Guiding Principles Framework for Action to Advance Integrated Territorial Development. UN-Habitat, Nairobi. https://urbanrurallinkages.files.wordpress.com/2019/09/url-gp-1.pdf

166 d'Amour, C.B., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K.H., Haberl, H., Creutzig, F. and Seto, K.C., 2017. Future urban land expansion and implications for global croplands. Proceedings of the National Academy of Sciences, 114(34), pp. 8939-8944. https://doi.org/10.1073/pnas.1606036114

167 van Vliet, J., 2019. Direct and indirect loss of natural area from urban expansion. Nature Sustainability, 2(8), pp.755-763. https://doi.org/10.1038/s41893-019-0340-0

168 Hatab, A.A., Cavinato, M.E.R., Lindemer, A. and Lagerkvist, C.J., 2019. Urban sprawl, food security and agricultural systems in developing countries: A systematic review of the literature. Cities, 94, pp.129-142. https://doi.org/10.1016/j.cities.2019.06.001

169 Crossman, N.D., Bryan, B.A., Ostendorf, B. and Collins, S., 2007. Systematic landscape restoration in the rural–urban fringe: meeting conservation planning and policy goals. Biodiversity and Conservation, 16(13), pp.3781-3802. https://doi.org/10.1007/s10531-007-9180-8

170 McDonald, R.I., Weber, K.F., Padowski, J., Boucher, T. and Shemie, D., 2016. Estimating watershed degradation over the last century and its impact on water-treatment costs for the world's large cities. Proceedings of the National Academy of Sciences, 113(32), pp.9117-9122. https://doi.org/10.1073/pnas.1605354113

171 UN-Habitat, 2015. International Guidelines on Urban and Territorial Planning. UN-Habitat, Nairobi. https://unhabitat.org/sites/default/files/download-manager-files/IG-UTP_English.pdf

172 UN-Habitat, 2016. Remaking the urban mosaic: Participatory and inclusive land readjustment. UN-Habitat, Nairobi. https://unhabitat.org/remaking-the-urban-mosaic-participatory-and-inclusive-land-readjustment

173 FAO, 2020. Land use in agriculture by the numbers. FAO, Rome. http://www.fao.org/sustainability/news/detail/en/c/1274219/

174 FAO, 2021. The State of the World's Land and Water Resources for Food and Agriculture – Systems at breaking point. Synthesis report 2021 (SOLAW 2021). FAO, Rome. https://doi.org/10.4060/cb7654en

175 Hodson E., Niggli U., Kitajima K., Lal R. and Sadoff C., 2021. Boost Nature Positive Production A Paper On Action Track 3. A paper from the Scientific Group of the UN Food Systems Summit July 18, 2021. United Nations Food Systems Summit 2021 Scientific Group. https://sc-fss2021.org/wp-content/uploads/2021/04/Action_Track_3_paper_Boost_Nature_Positive_Production.pdf

176 Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K. and Johns, C., 2020. What Is Regenerative Agriculture? A Review of Scholar and Practitioner Definitions Based on Processes and Outcomes. Frontiers in Sustainable Food Systems, 4, p.194. https://doi.org/10.3389/fsufs.2020.577723

177 Schreefel, L., Schulte, R.P.O., de Boer, I.J.M., Schrijver, A.P. and van Zanten, H.H.E., 2020. Regenerative agriculture: the soil is the base. Global Food Security, 26, p.100404. https://doi.org/10.1016/j.gfs.2020.100404

178 Di Falco, S. and Zoupanidou, E., 2017. Soil fertility, crop biodiversity, and farmers' revenues: Evidence from Italy. Ambio, 46(2), pp.162-172. https://doi.org/10.1007/s13280-016-0812-7

179 Lal, R. 2014. Abating Climate Change and Feeding the World Through Soil Carbon Sequestration. In Soil as World Heritage, edited by David Dent, 443–57. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-6187-2_47

180 International Institute of Rural Reconstruction and African Conservation Tillage Network, 2005. Conservation Agriculture: A Manual for Farmers and Extension Workers in Africa. IIRR, Nairobi and ACT, Harare. https://www.fsnnetwork.org/resource/conservation-agriculture-manual-farmers-and-extension-workers-africa

181 Muchane, M.N., Sileshi, G.W., Gripenberg, S., Jonsson, M., Pumariño, L. and Barrios, E., 2020. Agroforestry boosts soil health in the humid and sub-humid tropics: A meta-analysis. Agriculture, Ecosystems & Environment, 295, p.106899. https://doi.org/10.1016/j.agee.2020.106899

182 Martin, D.A., Osen, K., Grass, I., Hölscher, D., Tscharntke, T., Wurz, A. and Kreft, H., 2020. Land-use history determines ecosystem services and conservation value in tropical agroforestry. Conservation Letters, 13(5), p.e12740. https://doi.org/10.1111/conl.12740

183 Saffeullah, P., Nabi, N., Liaqat, S., Anjum, N.A., Siddiqi, T.O. and Umar, S., 2021. Organic Agriculture: Principles, Current Status, and Significance. In Microbiota and Biofertilizers (pp. 17-37). Springer, Cham. https://doi.org/10.1007/978-3-030-48771-3_2

184 Das, S., Chatterjee, A. and Pal, T.K., 2020. Organic farming in India: a vision towards a healthy nation. Food Quality and Safety, 4(2), pp.69-76. https://doi.org/10.1093/fqsafe/fyaa018

185 Holmgren, D., 2020. Essence of permaculture. Melliodora Publishing. https://melliodora.com/catalogue/essence-of-permaculture

186 Nedumaran, D.G. and Manida M., 2020. Sustainable Development and Challenges of Organic Farming Practices (10 March). http://doi.org/10.2139/ssrn.3551965

187 Sivanappan, R.K., 2006. Rainwater harvesting, conservation and management strategies for urban and rural sectors. In National Seminar on Rainwater Harvesting and Water Management (Vol. 11, No. 12, p. 1). https://www.researchgate.net/profile/Arvind-Singh-21/post/What_are_the_different_rain_water_harvesting_techniques_practiced_in_different_parts_of_the_world/attachment/59d6312779197b807798ef12/AS%3A364600588554241%401463938962485/download/2.pdf

188 De Pinto, A., Cenacchi, N., Kwon, H.Y., Koo, J. and Dunston, S., 2020. Climate smart agriculture and global food-crop production. PLoS One, 15(4), p.e0231764. https://doi.org/10.1371/journal.pone.0231764

189 FAO, 2022. Climate-Smart Agriculture. FAO, Rome. http://www.fao.org/climate-smart-agriculture/en

190 EurActive, 2015. Innovation – Feeding the world. Special Report (19-23 October). EurActive. https://euractiv.eu/wp-content/uploads/special-report/euractiv_special_report_-_innovation_feeding_the_world_0-1.pdf

191 Oliver, M.A., 2013. Precision agriculture and geostatistics: How to manage agriculture more exactly. Significance, 10(2), pp.17-22. https://doi.org/10.1111/j.1740-9713.2013.00646.x

192 Cockburn, J., Rosenberg, E., Copteros, A., Cornelius, S.F.A., Libala, N., Metcalfe, L. and van der Waal, B., 2020. A relational approach to landscape stewardship: Towards a new perspective for multi-actor collaboration. Land, 9(7), p.224. https://doi.org/10.3390/land9070224

193 Cannavò, P.F., 2007. The working landscape: Founding, preservation, and the politics of place. MIT Press, Cambridge, MA. https://doi.org/10.1017/S1537592708081462

194 Keenan, R.J., Reams, G.A., Achard, F., de Freitas, J.V., Grainger, A. and Lindquist, E., 2015. Dynamics of global forest area: Results from the FAO Global Forest Resources Assessment 2015. Forest Ecology and Management, 352, pp.9-20. https://doi.org/10.1016/j.foreco.2015.06.014

195 Dummett C., Blundell A., Canby K., Wolosin M., and Bodnar E., 2021. Illicit harvest, complicit goods. The state of illegal deforestation for agriculture. Forest policy trade and finance initiative report. Forest Trends. https://www.forest-trends.org/publications/illicit-harvest-complicit-goods

196 Secretariat of the Convention on Biological Diversity, 2020. Global Biodiversity Outlook 5. CBD, Montreal. https://www.cbd.int/gbo5

197 Liu, H., Gong, P., Wang, J., Clinton, N., Bai, Y. and Liang, S., 2020. Annual dynamics of global land cover and its long-term changes from 1982 to 2015. Earth System Science Data, 12(2), pp.1217-1243. https://doi.org/10.5194/essd-12-1217-2020

198 Meli, P., Holl, K.D., Rey Benayas, J.M., Jones, H.P., Jones, P.C., Montoya, D. and Moreno Mateos, D., 2017. A global review of past land use, climate, and active vs. passive restoration effects on forest recovery. Plos one, 12(2), p.e0171368. https://doi.org/10.1371/journal.pone.0171368

199 Poorter, L., Craven, D., Jakovac, C.C., van der Sande, M.T., Amissah, L., Bongers, F., Chazdon, R.L., Farrior, C.E., Kambach, S., Meave, J.A., Muñoz, R. et al., 2021. Multidimensional tropical forest recovery. Science, 374(6573), pp.1370-1376. https://doi.org/10.1126/science.abh3629

200 Crouzeilles, R., Beyer, H.L., Monteiro, L.M., Feltran-Barbieri, R., Pessôa, A.C., Barros, F.S., Lindenmayer, D.B., Lino, E.D., Grelle, C.E., Chazdon, R.L. and Matsumoto, M., 2020. Achieving cost-effective landscape-scale forest restoration through targeted natural regeneration. Conservation Letters, 13(3), p.e12709. https://doi.org/10.1111/conl.12709

201 Jones, H.P., Jones, P.C., Barbier, E.B., Blackburn, R.C., Rey Benayas, J.M., Holl, K.D., McCrackin, M., Meli, P., Montoya, D. and Mateos, D.M., 2018. Restoration and repair of Earth's damaged ecosystems. Proceedings of the Royal Society B: Biological Sciences, 285(1873), p.20172577. https://doi.org/10.1098/rspb.2017.2577

202 Wang, Y., Sun, Y., Wang, Z., Chang, S. and Hou, F., 2018. Grazing management options for restoration of alpine grasslands on the Qinghai-Tibet Plateau. Ecosphere, 9(11), p.e02515. https://doi.org/10.1002/ecs2.2515

203 Safriel U., Adeel Z., Niemeijer D., Puigdefabregas J., White R. Lal R., Winslow M., Ziedler J., Prince S., Archer E., King C. et al., 2005. Dryland Systems. In R. Hassan, R. Scholes, & N. Ash (Eds.), Ecosystems and Human Well-being: Current State and Trends.: Findings of the Condition and Trends Working Group (Vol. 1, pp. 623-662). Island Press. https://www.millenniumassessment.org/documents/document.291.aspx.pdf

204 Reij, C., Pasiecznik, N., Mahamoudou, S., Kassa, H., Winterbottom, R., Livingstone, J., 2020. Dryland restoration successes in the Sahel and Greater Horn of Africa show how to increase scale and impact. In. Pasiecznik, N. and C. Reij (eds.). Restoring African Drylands. ETFRN News (60): 1-24. https://hdl.handle.net/10568/111706

205 Humpenöder, F., Karstens, K., Lotze-Campen, H., Leifeld, J., Menichetti, L., Barthelmes, A. and Popp, A., 2020. Peatland protection and restoration are key for climate change mitigation. Environmental Research Letters, 15(10), p.104093. https://doi.org/10.1088/1748-9326/abae2a

206 Gross E, Jayasinghe N., Brooks A., Polet G., Wadhwa R., and Hilderink-Koopmans F., 2021. A Future for All: The Need for Human-Wildlife Coexistence. WWF, Gland. https://www.worldwildlife.org/publications/a-future-for-all-the-need-for-human-wildlife-coexistence

207 Dudley, N., 2013. IUCN WCPA Best Practice Guidance on Recognising Protected Areas and Assigning Management Categories and Governance Types, Best Practice Protected Area Guidelines Series No. 21. IUCN, Gland. https://portals.iucn.org/library/node/30018

208 Lehikoinen, P., Santangeli, A., Jaatinen, K., Rajasärkkä, A. and Lehikoinen, A., 2019. Protected areas act as a buffer against detrimental effects of climate change—Evidence from large-scale, long-term abundance data. Global Change Biology, 25(1), pp.304-313. https://doi.org/10.1111/gcb.14461

209 IPBES, 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Brondizio E. S., Settele J., Díaz S., and Ngo H. T. (editors). IPBES secretariat, Bonn. https://doi.org/10.5281/zenodo.3831673

210 Harrison, I.J., Green, P.A., Farrell, T.A., Juffe-Bignoli, D., Sáenz, L. and Vörösmarty, C.J., 2016. Protected areas and freshwater provisioning: a global assessment of freshwater provision, threats and management strategies to support human water security. Aquatic Conservation: Marine and Freshwater Ecosystems, 26, pp.103-120. https://doi.org/10.1002/aqc.2652

211 Secretariat of the Convention on Biological Diversity, 2020. Global Biodiversity Outlook 5. CBD, Montreal. https://www.cbd.int/gbo5

212 Wolf, C., Levi, T., Ripple, W.J., Zárrate-Charry, D.A. and Betts, M.G., 2021. A forest loss report card for the world's protected areas. Nature Ecology & Evolution, 5(4), pp.520-529. https://doi.org/10.1038/s41559-021-01389-0

213 Maxwell, S.L., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A.S., Stolton, S., Visconti, P., Woodley, S., Kingston, N., Lewis, E. and Maron, M., 2020. Area-based conservation in the twenty-first century. Nature, 586(7828), pp.217-227. https://doi.org/10.1038/s41586-020-2773-z

214 Albers, H.J., White, B., Robinson, E.J. and Sterner, E., 2020. Spatial protected area decisions to reduce carbon emissions from forest extraction. Spatial Economic Analysis, 15(3), pp.280-298. http://doi.org/10.1080/17421772.2019.1692143

215 Elsen, P.R., Monahan, W.B., Dougherty, E.R. and Merenlender, A.M., 2020. Keeping pace with climate change in global terrestrial protected areas. Science advances, 6(25), p.eaay0814. https://doi.org/10.1126/sciadv.aay0814

216 Dinerstein, E., Olson, D., Joshi, A., Vynne, C., Burgess, N.D., Wikramanayake, E., Hahn, N., Palminteri, S., Hedao, P., Noss, R. and Hansen, M., 2017. An ecoregion-based approach to protecting half the terrestrial realm. BioScience, 67(6), pp.534-545. https://doi.org/10.1093/biosci/bix014

217 Leberger, R., Rosa, I.M., Guerra, C.A., Wolf, F. and Pereira, H.M., 2020. Global patterns of forest loss across IUCN categories of protected areas. Biological Conservation, 241, p.108299. https://doi.org/10.1016/j.biocon.2019.108299

218 MacKinnon, K., Smith, R., Dudley, N., Figgis, P., Hockings, M., Keenleyside, K., Laffoley, D., Locke, H., Sandwith, T., Woodley, S. and Wong, M., 2020. Strengthening the global system of protected areas post-2020: A perspective from the IUCN World Commission on Protected Areas. In Parks Stewardship Forum (Vol. 36, No. 2). https://doi.org/10.5070/P536248273

219 Keenelyside, K., Dudley, N., Cairns, S., Hall, C. and Stolton, S., 2012. Ecological restoration for protected areas: principles, guidelines and best practices (Vol. 18). IUCN, Gland. https://www.iucn.org/content/ecological-restoration-protected-areas-principles-guidelines-and-best-practices

220 Dudley, N., Gonzales, E., Hallett, J.G., Keenleyside, K. and Mumba, M., 2020. The UN Decade on Ecosystem Restoration (2021–2030): What can Protected Areas Contribute? Parks 26, p.111. https://doi.org/10.2305/IUCN.CH.2020.PARKS-26-1ND.en

221 CMS, 2020. Resolution 12.26. https://www.cms.int/sites/default/files/document/cms_cop13_res.12.26_rev.cop13_e.pdf

222 Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J.P., Arafeh-Dalmau, N., Allan, J.R., Venter, O., Dubois, G. and Watson, J.E., 2020. Just ten percent of the global terrestrial protected area network is structurally connected via intact land. Nature communications, 11(1), pp.1-10. https://doi.org/10.1038/s41467-020-18457-x

223 Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A. and Dubois, G., 2019. Global trends in protected area connectivity from 2010 to 2018. Biological Conservation, 238, p.108183. https://doi.org/10.1016/j.biocon.2019.07.028

224 Santini, L., Saura, S. and Rondinini, C., 2016. Connectivity of the global network of protected areas. Diversity and Distributions, 22(2), pp.199-211. https://doi.org/10.1111/ddi.12390

225 Saura, S., Bastin, L., Battistella, L., Mandrici, A. and Dubois, G., 2017. Protected areas in the world's ecoregions: How well connected are they? Ecological indicators, 76, pp.144-158. https://doi.org/10.1016/j.ecolind.2016.12.047

226 IPBES, 2019. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Brondizio E. S., Settele J., Díaz S., and Ngo H. T. (editors). IPBES secretariat, Bonn. https://doi.org/10.5281/zenodo.3831673

227 Fuller, C., Ondei, S., Brook, B.W. and Buettel, J.C., 2019. First, do no harm: A systematic review of deforestation spillovers from protected areas. Global Ecology and Conservation, 18, p.e00591. https://doi.org/10.1016/j.gecco.2019.e00591

228 Deke, O., 2008. Preserving biodiversity as a global public good: protected areas and international transfers. Environmental policy instruments for conserving global biodiversity, pp.185-342. https://doi.org/10.1007/978-3-540-73748-3_4

229 Ghate, R., 2003. Global gains at local costs: Imposing protected areas: Evidence from Central India. The International Journal of Sustainable Development & World Ecology, 10(4), pp.377-389. https://doi.org/10.1080/13504500309470113

230 Montoya-Zumaeta, J.G., Wunder, S. and Tacconi, L., 2021. Incentive-based conservation in Peru: Assessing the state of six ongoing PES and REDD+ initiatives. Land Use Policy, 108, p.105514. https://doi.org/10.1016/j.landusepol.2021.105514

231 Figgis, P., Mackey, B., Fitzsimons, J., Irving, J. and Clarke, P., 2015. Valuing nature: protected areas and ecosystem services. Sydney: Australian Committee for IUCN. https://www.aciucn.org.au/publications

232 Schirpke, U., Marino, D., Marucci, A., Palmieri, M. and Scolozzi, R., 2017. Operationalising ecosystem services for effective management of protected areas: Experiences and challenges. Ecosystem Services, 28 (A), pp.105-114. https://doi.org/10.1016/j.ecoser.2017.10.009

233 Chen, X., Lupi, F. and Liu, J., 2017. Accounting for ecosystem services in compensating for the costs of effective conservation in protected areas. Biological Conservation, 215, pp.233-240. https://doi.org/10.1016/j.biocon.2017.09.013

234 Harilal, V., Tichaawa, T.M. and Saarinen, J., 2021. The Impacts of Ecotourism and Conservation Measures in Protected Areas on Local Communities in Cameroon. Tourism Review International, 25 (2-3) pp 89-103(15). https://doi.org/10.3727/154427220X16092157169853

235 Naidoo, R., Gerkey, D., Hole, D., Pfaff, A., Ellis, A.M., Golden, C.D., Herrera, D., Johnson, K., Mulligan, M., Ricketts, T.H. and Fisher, B., 2019. Evaluating the impacts of protected areas on human well-being across the developing world. Science Advances, 5(4), p.eaav3006. https://doi.org/10.1126/sciadv.aav3006

236 Shah, P., Baylis, K., Busch, J. and Engelmann, J., 2021. What determines the effectiveness of national protected area networks? Environmental Research Letters. https://doi.org/10.1088/1748-9326/ac05ed

237 Dhama, K., Patel, S.K., Sharun, K., Pathak, M., Tiwari, R., Yatoo, M.I., Malik, Y.S., Sah, R., Rabaan, A.A., Panwar, P.K. and Singh, K.P., et al., 2020. SARS-CoV-2 jumping the species barrier: zoonotic lessons from SARS, MERS and recent advances to combat this pandemic virus. Travel medicine and infectious disease, p.101830. https://doi.org/10.1016/j.tmaid.2020.101830

238 FAO, 2021. The impact of disasters and crises on agriculture and food security: 2021. FAO, Rome. https://doi.org/10.4060/cb3673en

239 ILO, 2020. ILO Monitor: COVID-19 and the world of work. Fifth edition. Updated estimates and analysis. ILO, Geneva. https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/briefingnote/wcms_749399.pdf

240 The World Bank, 2020. How does informality aggravate the impact of COVID-19? Box1.4 in: Chapter 1, Pandemic, Recession: the Global Economy in Crisis. In: World Bank, 2020. Issue Global Economic Prospects. A World Bank Group Flagship Report (June). World Bank, Washington, DC. https://openknowledge.worldbank.org/bitstream/handle/10986/33748/211553-Ch01.pdf

241 Mahler D.G., Yonzan N., Lakner C., Castaneda Aguilar A., and Wu H., 2021. Updated estimates of the impact of COVID-19 on global poverty: Turning the corner on the pandemic in 2021? World Bank Blogs (24 June). https://blogs.worldbank.org/opendata/updated-estimates-impact-covid-19-global-poverty-turning-corner-pandemic-2021

242 FAO, IFAD, UNICEF, WFP, and WHO, 2021. The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. FAO, Rome. https://doi.org/10.4060/cb4474en

243 Vivid Economics, Finance for Biodiversity Initiative, 2021. Greenness of Stimulus Index (GSI). Vivid Economics, Finance for Biodiversity Initiative. https://www.vivideconomics.com/wp-content/uploads/2021/01/201214-GSI-report_December-release.pdf

244 Finance for Biodiversity Initiative, 2021. Majority of $17.2 Trillion Covid Stimulus Packages "Doing More Harm Than Good" to Environment. F4B (15 July). https://www.f4b-initiative.net/post/majority-of-17-2-trillion-covid-stimulus-packages-doing-more-harm-than-good-to-environment

245 Das M.B., Espinoza S.A., Ijjasz-Vasquez E. J., Choi N., and Sultan S. M., 2020. The Human Face of COVID-19: Six Things to Consider for an Inclusive Recovery. The World Bank, Washington, DC. (22 October). https://www.worldbank.org/en/news/immersive-story/2020/10/22/the-human-face-of-covid-19-six-things-to-consider-for-an-inclusive-recovery

246 Hepburn, C., O'Callaghan, B., Stern, N., Stiglitz, J., and Zenghelis, D. 2020. Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change? Smith School Working Paper 20-02. https://www.smithschool.ox.ac.uk/publications/wpapers/workingpaper20-02.pdf

247 Engel H., Hamilton A., Hieronimus S., Naucler T. et al., 2020. How a post-pandemic stimulus can both create jobs and help the climate. McKinsey Sustainability (27 May). https://www.mckinsey.com/business-functions/sustainability/our-insights/how-a-post-pandemic-stimulus-can-both-create-jobs-and-help-the-climate

248 Barbier, E.B., 2020. Greening the post-pandemic recovery in the G20. Environmental and Resource Economics, 76(4), pp.685-703. https://doi.org/10.1007/s10640-020-00437-w

249 Barbier, E.B., 2020. Greening the post-pandemic recovery in the G20. Environmental and Resource Economics, 76(4), pp.685-703. https://doi.org/10.1007/s10640-020-00437-w

250 Batini, N., Di Serio, M., Fragetta, M., Melina, G. and Waldron, A., 2021. Building Back Better: How Big Are Green Spending Multipliers? IMF Working Papers, 2021(087). https://www.imf.org/en/Publications/WP/Issues/2021/03/19/Building-Back-Better-How-Big-Are-Green-Spending-Multipliers-50264

251 World Economic Forum, 2020. The Future of Nature and Business. New Nature Economy Report II. WEF, Geneva. https://www3.weforum.org/docs/WEF_The_Future_Of_Nature_And_Business_2020.pdf

252 Squires, V.R. (ed.), 2012. Rangeland Stewardship in Central Asia: Balancing improved livelihoods, biodiversity conservation and land protection. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-5367-9

253 Leake, J.E., 2021. Investment in Land Restoration: New Perspectives with Special Reference to Australia. Land, 10(2), p.156. https://doi.org/10.3390/land10020156

254 Sewell, A., Bouma, J., and van der Esch, S., 2016. Investigating the challenges and opportunities for scaling up Ecosystem Restoration, The Hague: PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/investigating-the-challenges-and-opportunities-for-scaling-up-ecosystem-restoration

255 FAO, UNDP and UNEP, 2021. A multi-billion-dollar opportunity – Repurposing agricultural support to transform food systems. FAO, Rome. https://doi.org/10.4060/cb6562en

256 Dasgupta, P., 2021. The Economics of Biodiversity: the Dasgupta Review. London, HM Treasury. https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

257 LaCanne, C.E. and Lundgren, J.G., 2018. Regenerative agriculture: merging farming and natural resource conservation profitably. PeerJ, 6, p.e4428. https://doi.org/10.7717/peerj.4428

258 Rodriguez Echandi C. M., and Thiaw I., 2021. How rescheduling debt for climate and nature goals could unlock a sustainable recovery. World Economic Forum (25 March). https://www.weforum.org/agenda/2021/03/rescheduling-debt-climate-sustainable-recovery

259 Aslam Khan M.A., 2021. How Pakistan is aiming for a green recovery from the pandemic. World Economic Forum (12 February). https://www.weforum.org/agenda/2021/02/pakistan-green-recovery

260 Busch, J., Ring, I., Akullo, M., Amarjargal, O., Borie, M., Cassola, R.S., Cruz-Trinidad, A., Droste, N., Haryanto, J.T., Kasymov, U. and Kotenko, N.V., 2021. A global review of ecological fiscal transfers. Nature Sustainability, pp.1-10. https://doi.org/10.1038/s41893-021-00728-0

261 OECD, 2021. Towards gender-inclusive recovery, OECD Policy Responses to Coronavirus (COVID-19). OECD Publishing, Paris. https://doi.org/10.1787/ab597807-en

262 OECD, 2021. The territorial impact of COVID-19: Managing the crisis and recovery across levels of government, OECD Policy Responses to Coronavirus (COVID-19). OECD Publishing, Paris. https://doi.org/10.1787/a2c6abaf-en

263 OECD, 2020. Making the green recovery work for jobs, income and growth, OECD Policy Responses to Coronavirus (COVID-19). OECD Publishing, Paris. https://doi.org/10.1787/a505f3e7-en.

264 OECD, 2021. Paris collaborative on green budgeting. OECD, Paris. https://www.oecd.org/environment/green-budgeting

265 Cunningham, S., 2002. The restoration economy: the greatest new growth frontier. Berrett-Koehler Publishers. http://www.worldcat.org/oclc/664102527

266 BenDor, T., Lester, T.W., Livengood, A., Davis, A. and Yonavjak, L., 2015. Estimating the size and impact of the ecological restoration economy. PloS one, 10(6), p.e0128339. https://doi.org/10.1371/journal.pone.0128339

267 Mansuy, N., 2020. Stimulating post-COVID-19 green recovery by investing in ecological restoration. Restoration Ecology, 28(6), pp.1343-1347. https://doi.org/10.1111/rec.13296

268 BenDor, T., Lester, T.W., Livengood, A., Davis, A. and Yonavjak, L., 2015. Estimating the size and impact of the ecological restoration economy. PloS one, 10(6), p.e0128339. https://doi.org/10.1371/journal.pone.0128339

269 United Nations et. al., 2021. System of Environmental Economic Accounting – Ecosystem Accounting (SEEA EA), White cover publication, pre-edited text subject to official editing. https://seea.un.org/ecosystem-accounting

270 UN System of Environmental Economic Accounting, 2021. Ecosystem Accounting in the News. UN SEEA, New York. https://seea.un.org/content/ecosystem-accounting-news

271 Mansuy, N., 2020. Stimulating post-COVID-19 green recovery by investing in ecological restoration. Restoration Ecology, 28(6), pp.1343-1347. https://doi.org/10.1111/rec.13296

272 Bendor, T. K., Livengood, A., Lester, T. W., Davis, A., and Yonavjak, L., 2015. Defining and evaluating the ecological restoration economy. Restoration Ecology 23(3): 209–219. Blackwell Publishing. https://doi.org/10.1111/rec.12206

273 New Climate Economy, The Global Commission on the Economy and Climate, 2018. Unlocking the Inclusive Growth Story of the 21st Century: Accelerating Climate Action in Urgent Times. New Climate Economy, Washington DC. https://newclimateeconomy.report/2018

274 Mansuy, N. and MacAfee, K., 2019. More than planting trees: career opportunities in ecological restoration. Frontiers in Ecology and the Environment, 17(6), pp.355-356. https://doi.org/10.1002/fee.2083

275 Kellon, C.P. and Hesselgrave, T., 2014. Oregon's Restoration Economy: How investing in natural assets benefits communities and the regional economy. SAPIENS. Surveys and Perspectives Integrating Environment and Society, (7.2). https://journals.openedition.org/sapiens/1599

276 United Nations, 2020. A UN framework for the immediate socio-economic response to COVID-19. UN, New York. https://unsdg.un.org/resources/un-framework-immediate-socio-economic-response-covid-19

277 Bernstein, A.S., Ando, A.W., Loch-Temzelides, T., Vale, M.M., Li, B.V., Li, H., Busch, J., Chapman, C.A., Kinnaird, M., Nowak, K. and Castro, M.C., 2022. The costs and benefits of primary prevention of zoonotic pandemics. Science Advances, 8(5), p.eabl4183. https://doi.org/10.1126/sciadv.abl4183

278 Wildlife Conservation Society, 2021. The Manhattan Principles. WCS One World One Health. https://oneworldonehealth.wcs.org/About-Us/Mission/The-Manhattan-Principles.aspx

279 Centers for Disease Control and Prevention, 2022. One Health. CDC, Atlanta. https://www.cdc.gov/onehealth/index.html

280 Nhamo, L. and Ndlela, B., 2021. Nexus planning as a pathway towards sustainable environmental and human health post Covid-19. Environmental Research, 192, p.110376. https://doi.org/10.1016/j.envres.2020.110376

281 Reaser, J.K., Witt, A., Tabor, G.M., Hudson, P.J. and Plowright, R.K., 2021. Ecological countermeasures for preventing zoonotic disease outbreaks: when ecological restoration is a human health imperative. Restoration Ecology, p.e13357. https://doi.org/10.1111/rec.13357

282 Lal, R. ed., 2021. Soil Organic Carbon and Feeding the Future: Basic Soil Processes. CRC Press. https://doi.org/10.1201/9781003243090

283 Plowright, R.K., Reaser, J.K., Locke, H., Woodley, S.J., Patz, J.A., Becker, D.J., Oppler, G., Hudson, P.J. and Tabor, G.M., 2021. Land use-induced spillover: a call to action to safeguard environmental, animal, and human health. The Lancet Planetary Health. https://doi.org/10.1016/S2542-5196(21)00031-0

284 Breed, M.F., Cross, A.T., Wallace, K., Bradby, K., Flies, E., Goodwin, N., Jones, M., Orlando, L., Skelly, C., Weinstein, P. and Aronson, J., 2020. Ecosystem restoration: a public health intervention. EcoHealth, pp.1-3. https://doi.org/10.1007/s10393-020-01480-1

285 Coad L., Willis J., Maisels F., Funk S., Doughty H., Fa J.E., Gomez J., Ingram D.J., Li Y., Nihotte L., Paemelaere E., Sartoretto E., van Vliet N. and Nasi R., 2021. Impacts of taking, trade and consumption of terrestrial migratory species for wild meat. CMS, Bonn. https://www.cms.int/sites/default/files/publication/CMS_Report_impacts_wild_meat_terrestrial_migratory_species.pdf

286 Wu, T., 2021. The socioeconomic and environmental drivers of the COVID-19 pandemic: A review. Ambio, pp.1-12. https://doi.org/10.1007/s13280-020-01497-4

287 Chin, A., Cui, X., Gillson, L., Nelson, D., Taylor, M.P., Vanacker, V. and Wang, E., 2020. Anthropocene in an age of pandemics. Anthropocene, 30, p.100247. https://doi.org/10.1016/j.ancene.2020.100247

288 Recht, J., Schuenemann, V.J. and Sánchez-Villagra, M.R., 2020. Host diversity and origin of zoonoses: the ancient and the new. Animals, 10(9), p.1672. https://doi.org/10.3390/ani10091672

289 UNEP, 2016. UNEP Frontiers 2016 Report: Emerging Issues of Environmental Concern. United Nations Environment Programme, Nairobi. https://www.unenvironment.org/resources/frontiers-2016-emerging-issues-environmental-concern

290 Petrikova, I., Cole, J. and Farlow, A., 2020. COVID-19, wet markets, and planetary health. The Lancet Planetary Health, 4(6), p.e213. https://doi.org/10.1016/S2542-5196(20)30122-4

291 Aguirre, A.A., Catherina, R., Frye, H. and Shelley, L., 2020. Illicit wildlife trade, wet markets, and COVID-19: preventing future pandemics. World Medical & Health Policy, 12(3), pp.256-265. https://doi.org/10.1002/wmh3.348

292 Roe, D., Dickman, A., Kock, R., Milner-Gulland, E.J. and Rihoy, E., 2020. Beyond banning wildlife trade: COVID-19, conservation and development. World Development, 136, p.105121. https://doi.org/10.1016/j.worlddev.2020.105121

293 Wardell, D.A., Piketty, M.G., Lescuyer, G. and Pacheco, P., 2021. Reviewing initiatives to promote sustainable supply chains: The case of forest-risk commodities. Working Paper 8. The CGIAR Research Program on Forests, Trees and Agroforestry (FTA), Bogor. https://doi.org/10.17528/cifor/007944

294 van't Veen, H., Eppinga, M.B., Mwampamba, T.H. and Dos Santos, M.J.F., 2021. Long term impacts of transitions in charcoal production systems in tropical biomes. Environmental Research Letters, 16(3), p.034009. https://doi.org/10.1088/1748-9326/abe14d

295 Garcés, L., 2020. COVID-19 exposes animal agriculture's vulnerability. Agriculture and human values, 37, pp.621-622. https://doi.org/10.1007/s10460-020-10099-5

296 Jeong, S.H., Kang, D., Lim, M.W., Kang, C.S. and Sung, H.J., 2010. Risk assessment of growth hormones and antimicrobial residues in meat. Toxicological research, 26(4), pp.301-313. https://doi.org/10.5487/tr.2010.26.4.301

297 WHO, 2017. Stop using antibiotics in healthy animals to prevent the spread of antibiotic resistance. https://www.who.int/news/item/07-11-2017-stop-using-antibiotics-in-healthy-animals-to-prevent-the-spread-of-antibiotic-resistance

298 FAO, 2012. Sustainable Diets and Biodiversity: Directions and Solutions for Policy, Research and Action. FAO, Rome. http://www.fao.org/3/i3004e/i3004e.pdf

299 Ritchie H., 2017. How much of the world's land would we need in order to feed the global population with the average diet of a given country? Our World in Data (03 October). https://ourworldindata.org/agricultural-land-by-global-diets

300 Rust, N.A., Ridding, L., Ward, C., Clark, B., Kehoe, L., Dora, M., Whittingham, M.J., McGowan, P., Chaudhary, A., Reynolds, C.J. and Trivedy, C., 2020. How to transition to reduced-meat diets that benefit people and the planet. Science of the Total Environment, 718, p.137208. https://doi.org/10.1016/j.scitotenv.2020.137208

301 Landrigan, P.J., Fuller, R., Acosta, N.J., Adeyi, O., Arnold, R., Baldé, A.B., Bertollini, R., Bose-O'Reilly, S., Boufford, J.I., Breysse, P.N., Chiles, T. et al., 2018. The Lancet Commission on pollution and health. The Lancet, 391(10119), pp.462-512. https://doi.org/10.1016/S0140-6736(17)32345-0

302 Xia, Y., Zhang, M., Tsang, D.C., Geng, N., Lu, D., Zhu, L., Igalavithana, A.D., Dissanayake, P.D., Rinklebe, J., Yang, X. and Ok, Y.S., 2020. Recent advances in control technologies for non-point source pollution with nitrogen and phosphorous from agricultural runoff: current practices and future prospects. Applied Biological Chemistry, 63(1), pp.1-13. https://doi.org/10.1186/s13765-020-0493-6

303 Wu, Y., Wen, B., Li, S. and Guo, Y., 2021. Sand and dust storms in Asia: a call for global cooperation on climate change. The Lancet Planetary Health. https://doi.org/10.1016/S2542-5196(21)00082-6

304 United Nations, 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations Office for Disaster Risk Reduction, Geneva. https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

305 FAO, 2021. The impact of disasters and crises on agriculture and food security: 2021. FAO, Rome. https://doi.org/10.4060/cb3673en

306 Scheper, A.C., Verweij, P.A. and van Kuijk, M., 2021. Post-fire forest restoration in the humid tropics: A synthesis of available strategies and knowledge gaps for effective restoration. Science of The Total Environment, 771, p.144647. https://doi.org/10.1016/j.scitotenv.2020.144647

307 Mizutori, M. and Guha-Sapir, D., 2017. Economic losses, poverty and disasters 1998–2017. Centre for Research on the Epidemiology of Disasters (CRED), United Nations Office for Disaster Risk Reduction, Geneva. https://www.undrr.org/publication/economic-losses-poverty-disasters-1998-2017

308 High-Level Panel on Water, 2018. Making every drop count- An agenda for water action. UN DESA, New York. https://sustainabledevelopment.un.org/content/documents/17825HLPW_Outcome.pdf

309 Veolia Water and the International Food Policy Research Institute, 2011. Sustaining growth via water productivity: 2030/2050 scenarios. IFPRI, Washington, DC and Veolia Water North America, Chicago. https://www.ifpri.org/publication/sustaining-growth-water-productivity-20302050-scenarios

310 Veolia Water, 2011. Greater efficiency in water management will reduce risk for half of the Global Economy. 3BL CSR Wire (21 March). https://www.csrwire.com/press_releases/31835-greater-efficiency-in-water-management-will-reduce-risk-for-half-of-the-global-economy

311 Cosgrove, W.J. and Loucks, D.P., 2015. Water management: Current and future challenges and research directions. Water Resources Research, 51(6), pp.4823-4839. https://doi.org/10.1002/2014WR016869

312 Elagib, N.A., Al Zayed, I.S., Saad, S.A.G., Mahmood, M.I., Basheer, M. and Fink, A.H., 2021. Debilitating floods in the Sahel are becoming frequent. Journal of Hydrology, 599, p.126362. https://doi.org/10.1016/j.jhydrol.2021.126362

313 Rentschler, J. and Salhab, M., 2020. People in Harm's Way: Flood Exposure and Poverty in 189 Countries. Policy Research Working Paper, No. 9447. World Bank, Washington, DC. http://hdl.handle.net/10986/34655

314 Cunniff, S.E., 2019. Scaling protection and restoration of natural infrastructure to reduce flood impacts and enhance resilience. Shore & Beach, 87(4), p.51. http://doi.org/10.34237/1008746

315 United Nations Environment Programme, 2022. Spreading like Wildfire – The Rising Threat of Extraordinary Landscape Fires. A UNEP Rapid Response Assessment. UNEP, Nairobi. https://www.unep.org/resources/report/spreading-wildfire-rising-threat-extraordinary-landscape-fires

316 Bowman, D.M., Kolden, C.A., Abatzoglou, J.T., Johnston, F.H., van der Werf, G.R. and Flannigan, M., 2020. Vegetation fires in the Anthropocene. Nature Reviews Earth & Environment, 1(10), pp.500-515. https://doi.org/10.1038/s43017-020-0085-3

317 Xu, R., Yu, P., Abramson, M.J., Johnston, F.H., Samet, J.M., Bell, M.L., Haines, A., Ebi, K.L., Li, S. and Guo, Y., 2020. Wildfires, global climate change, and human health. New England Journal of Medicine, 383(22), pp.2173-2181. https://doi.org/10.1056/NEJMsr2028985

318 Dube, O.P., 2007. Fire weather and land degradation. In Climate and land degradation (pp. 223-251). Springer, Berlin and Heidelberg. https://doi.org/10.1007/978-3-540-72438-4_12

319 UNCCD, 1994. United Nations Convention to Combat Desertification: Convention Text. https://www.unccd.int/sites/default/files/relevant-links/2017-01/UNCCD_Convention_ENG_0.pdf

320 Huang, J., Zhang, G., Zhang, Y., Guan, X., Wei, Y. and Guo, R., 2020. Global desertification vulnerability to climate change and human activities. Land Degradation & Development, 31(11), pp.1380-1391. https://doi.org/10.1002/ldr.3556

321 IPCC, 2019. Desertification. Chapter 3. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/srccl/chapter/chapter-3

322 Middleton, N. and Kang, U., 2017. Sand and dust storms: Impact mitigation. Sustainability, 9(6), p.1053. https://doi.org/10.3390/su9061053

323 Middleton, N., Tozer, P. and Tozer, B., 2019. Sand and dust storms: underrated natural hazards. Disasters, 43(2), pp.390-409. https://doi.org/10.1111/disa.12320

324 UNEP, WMO, and UNCCD. 2016. Global Assessment of Sand and Dust Storms. UNEP, Nairobi. https://wesr.unep.org/redesign/media/docs/assessments/global_assessment_of_sand_and_dust_storms.pdf

325 Sivakumar, M.V., 2005. Impacts of sand storms/dust storms on agriculture. Chapter 10 in: Sivakumar M.V.K., Motha R.P., Das H.P., Natural disasters and extreme events in agriculture (pp. 159-177). Springer, Berlin and Heidelberg. https://link.springer.com/chapter/10.1007/3-540-28307-2_10

326 IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., Barros V., Stocker T.F., Qin D., Dokken D.J., Ebi K.L., Mastrandrea M.D., Mach K.J.,. Plattner G.-K, Allen S.K., Tignor M., and Midgley P.M. (eds.)]., Cambridge University Press, UK and New York, 582 pp. https://www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation

327 Harari, N., Gavilano, A. and Liniger, H., 2017. Where people and their land are safer: a compendium of good practices in disaster risk reduction. Bern and Lucerne, Switzerland: Centre for Development and Environment (CDE), University of Bern, and Swiss NGO Disaster Risk Reduction (DRR) Platform, with Bern Open Publishing. https://www.shareweb.ch/site/DRR/Documents/To%20sort/Experience%20shared%20by%20members/CDE-DRRPlaftorm-WOCAT-01117.pdf

328 https://www.shareweb.ch/site/DRR/Documents/To%20sort/Experience%20shared%20by%20members/CDE-DRRPlaftorm-WOCAT-01117.pdf

PART TWO:
RESTORATION AROUND THE WORLD

Land restoration is gathering pace around the world. Strategies, approaches, and practices reflect the location, context, and scale. In most cases, the restoration activities that effectively tackle past land degradation are the same as those needed to prepare for future land challenges. Land restoration is a no regrets option, in that any effort to recover soil health, replenish natural capital, and restore land health will ultimately deliver benefits that far exceed the costs.

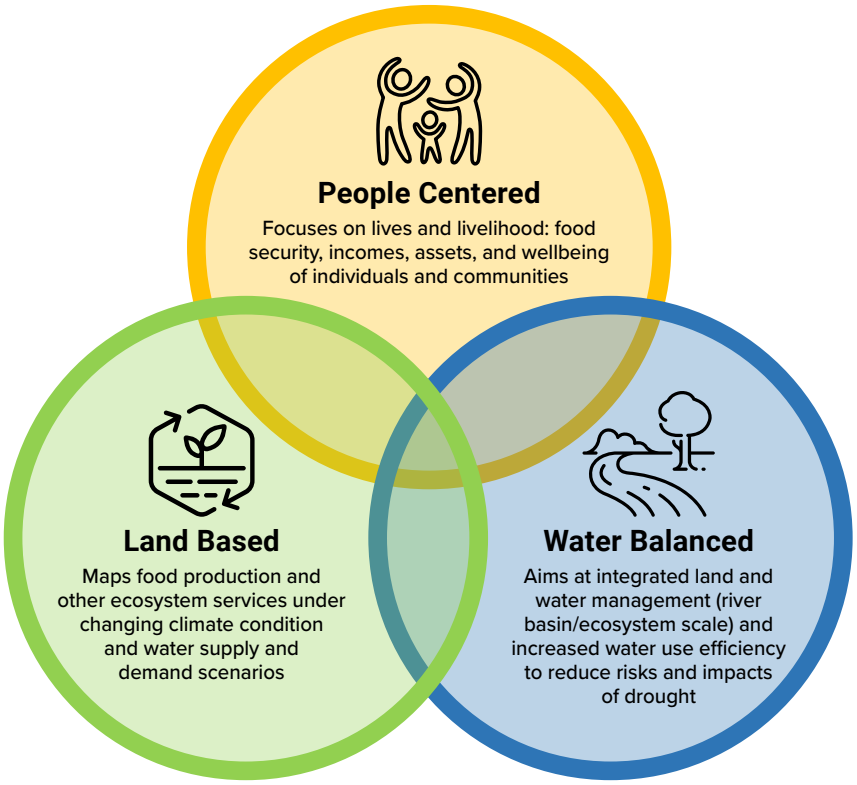
Part Two is a distillation of the multitude of land restoration activities – projects, programs, and initiatives – currently happening around the world. It illustrates the diversity of restoration objectives, strategies, and practices that seek to improve the health of land resources for the benefit of people and the planet. **Section One** (*Disaster Risk Reduction*) examines how countries and communities are preparing for and reducing the risk and impacts of drought, water scarcity, and other disasters associated with land degradation, biodiversity loss, and climate change. **Section Two** (*Land Governance and Tenure Security*) follows with case examples that focus on the nexus of land governance, vulnerable or disenfranchised populations, and the role of regenerative land and water management practices. **Section Three** (*Place-based Restoration*) presents some recent cases in specific land use contexts demonstrating that regenerative actions can be taken just about anywhere. Part Two concludes with a snapshot of regional efforts to build and sustain a Great Green Wall in Africa.

2.1.1 DROUGHT PREPAREDNESS AND RISK REDUCTION

Drought exists when precipitation has been significantly below normal recorded levels.[1] Ensuing water shortages and accompanying heat stresses disproportionately impact food production in all parts of the world. Drought risk is higher in regions that are extensively exploited for crop production and livestock raising due to the widespread loss of natural vegetation associated with these activities.[2] Globally, an estimated 55 million people are directly affected by drought every year, with most of the loss and damage occurring in lower-income countries.[3] Forests and grasslands deprived of rain are prone to wildfires; in cities, water taps run dry as reservoirs and wells empty.

Drought is often regarded as a slow-onset disaster – one that can be predicted and where preparedness measures can be taken. But 'flash droughts' can occur unexpectedly when climate change exposes normally wet areas to lengthy dry periods.[4] When drought hits, news headlines are filled with disturbing images and emergency relief efforts are activated though such efforts frequently remain under-resourced.[5] Helping communities prepare for drought before it occurs is far more effective and cheaper than reacting to a drought crisis.[6] Sustainable land and water management practices can significantly reduce the impacts of drought, especially when economic incentives for restoration are aligned with early warning, monitoring, and multi-scale governance.[7]

FIGURE 2.1 UNCCD Drought Initiative



The **UNCCD Drought Initiative** works to enhance the resilience of communities and ecosystems to drought by developing national action plans. Its goal is to promote a paradigm shift in approaches to the way drought is managed – pivoting from a reactive and crisis-based approach towards a proactive and risk-based one. Many countries soon expected to face intense climate change-driven drought still lack a comprehensive plan of action to implement at the first signs of drought. The UNCCD supports over 70 countries with practical tools for improving water management and designing comprehensive national plans of action to promote drought preparedness.

A proactive approach to drought risk management includes preparedness measures, coupled with related planning tools and stakeholder participation.[8]

In **Mexico**, widespread and recurrent drought between 2010 and 2013 led to the formation of the National Program against Drought. The program includes tools for a new proactive approach to integrated drought management at the level of basin councils, including communication, education, and innovation as part of a strategy to increase preparedness among water users.[9] In the USA, the National Drought Mitigation Center focuses on issues of drought monitoring, impact assessment, mitigation, and preparedness. The National Integrated Drought Information System explicitly calls for "enabling the nation to move from a reactive to a more proactive approach to managing drought risks and impacts".[10]

In **Brazil**, the Aridas Project is a collaborative effort between federal and state governments and non-governmental organizations. The project has developed a long-term planning methodology for sustainable development in the semi-arid northeast region of the country, with drought preparedness at its core. Good practices include drought-tolerant species selection, utilization of climate forecasts, boosting soil moisture retention capacities, and the adoption of rainwater harvesting techniques.[11] In the **Caribbean**, recent multi-year droughts have been severe, prompting the Caribbean Disaster Emergency Management Agency to implement a system for issuing drought alerts and warnings. While national water management authorities continue to lead individual country responses, the Caribbean Water and Wastewater Association is tasked with regional planning for future readiness actions.[12]


© Nam Nguyen Than

Sustainable land and soil management practices can reduce water scarcity and enhance drought resilience.[13]

In **Ethiopia**, smallholders use a range of strategies to reduce their vulnerability to drought while increasing productivity. These include rotating and diversifying crops, drip irrigation, and stress-resistant crop varieties.[14] Soil and water conservation methods, like the use of check dams and tied ridging, stop gully erosion and improve water infiltration in soils, preventing downstream flooding and rising water tables.[15] In **Malawi**, intercropping Gliricidia, a legume tree, with maize, improves long-term soil fertility with the leaf litter, providing inexpensive organic fertilizer. Fields managed in this way hold about 50% more water two weeks after rainfall than soils in maize monocultures.[16]

In **Southern Africa**, droughts increase the incidence of wildlife poaching as local people seek other sources of food and income.[17] While the vegetation in these areas can recover quickly after a drought,[18] endangered animal populations often cannot. As a result, it may be necessary to provide supplementary feed while helping local communities avoid conflict with wildlife during times of drought.[19] In **Burkina Faso**, the construction of stone bunds, known as diguettes, hold back rainwater and allow it to soak into the soil rather than run off. Supported by NGOs, peer-to-peer learning has led to their widespread use over the last 30 years, improving food security and reversing land degradation and desertification.[20]

In **Sweden**, the Tullstorpsån project promotes water storage in multifunctional wetlands to counter both drought and flash floods as well as to reduce nitrogen and phosphorus leaching into the Baltic.[21] Between 2009 and 2019, a total of 39 wetlands covering 169 hectares and 10 kilometers of watercourse margins were restored, providing improved access to farm fields and opportunities for outdoor recreation and tourism.[22] In **Germany**, as in the western USA, Australia, and the Mediterranean basin, droughts have led to devastating wildfires and pest invasions, such as bark beetles. The German government is considering a massive reafforestation program to make forests more resilient.[23] This involves planting trees that can adapt to future climate conditions, including native species and those from warmer southern European climates.[24]

Pakistan and India: Managed Aquifer Recharge

In the province of **Balochistan**, Pakistan, indigenous management techniques, known as the *karez* system, utilize tunnels that follow a natural gradient to deliver groundwater without employing mechanical energy. While these systems are community-based and robust over long periods, they are often unable to compete with the large-scale promotion and subsidies for dug and tube wells.[25] In many districts of **Gujarat**, India, water management systems, known as *holiyas*, came into use in the mid-1990s through spontaneous farmer-to-farmer transmission.[26] During heavy rains and floods, *holiyas* funnel and store rainwater below the land surface so that when water is scarce, the groundwater can be accessed and distributed using solar pumps.[27 28] Farmers can harvest water for about 10 days per year to generate a store of water to last up to seven months.[29] Both *karez* and *holiyas* are cost-effective systems that help mitigate drought, floods, and other climate stresses, contributing to more stable food production and livelihoods for local communities.

In the last two decades, plant breeding techniques and drought tolerance research have focused on staple crops that thrive even when rains fail.[30]

In **Burundi**, climate change is disrupting seasonal rainfall patterns. A project in the Moso region has reintroduced indigenous varieties of yam, cowpea, cajan pea, sorghum, and taro that tolerate drought better than modern cultivars. It combines seed collection and certification with demonstration plots and cooking fairs to promote their production and consumption.[31] In **Zimbabwe**, drought-tolerant maize varieties have been developed for mild drought conditions. Household surveys indicate that these varieties resulted in higher yields and generated an extra income of USD 240 per hectare or nine months of food at no additional cost.[32]
In **Nepal**, stress-tolerant rice varieties have been developed and widely adopted in the mid-hills region, where drought is a significant concern. Tolerant of floods and water scarcity, these varieties are also high yielding and can improve food security and household income even in non-drought years.[33]

In Latin America, drought-tolerant varieties of beans and potatoes are being developed to help farmers prosper in a changing climate.[34] In **El Salvador**, the national agricultural research institute has bred a drought-tolerant variety of light-red beans, known as CENTA EAC, by crossing red and black beans.[35] In **Guatemala**, researchers have released a bean variety, known as ICTA Chorti, which is enriched in iron and zinc but also drought-resistant.[36] In **Colombia**, scientists have identified wild ancestors of the tepary bean as a source of genes that can be reintroduced into cultivated beans to make them more drought- and heat-tolerant.[37] In **Peru**, researchers are studying wild relatives of the sweet potato that can maintain green leaves and tolerate longer periods of drought by regulating their leaf temperature. These physiological traits or stress memory hold great potential as a source of valuable traits for sweet potato breeding programs.[38]

The impacts and costs of drought can be extensive in urban areas, often involving multiple sectors with the potential to aggravate social tensions.[39]

One in four cities already suffers from water stress.[40] Many urban centers rely on rural watersheds for their water supply. Between 2000 and 2020, 79 large cities around the world suffered from drought.[41] Drought aggravates existing supply problems, reducing both the quantity and quality of water available. Poor urban residents are most affected – as communal taps dry up, they must rely on polluted water sources, or expensive bottled and tanker supplies. Many city governments are realizing the cost-effectiveness of addressing drought and water scarcity through watershed management and by reducing demand.

In **South Africa**, during the 2017–2018 drought, Cape Town instituted a graduated protocol to deal with water shortages.[42] Steps included the raising of water prices, rationing of supplies, prohibition of certain uses, and awareness-raising campaigns, including education on Day Zero – the expected day at which domestic supply would be entirely cut off unless consumption was curbed.[43] In general, non-price mechanisms are more effective and equitable as they give local authorities more control over the amount of water used and do not impose additional income burdens on the poor.

In **Australia**, periodic droughts are natural occurrences, driven by changes in the El Niño–Southern Oscillation. They are often accompanied by heatwaves and wildfires, which devastate large areas of natural vegetation and are thought to have driven some species to extinction.[44] Dams supply some 90% of the country's total water supplies, but storage levels drop drastically during prolonged drought. Cities have responded by diversifying water supplies and launching campaigns to reduce domestic usage, including the promotion of water-saving toilets, shower heads, and washing machines, as well as providing rebates to homeowners who install rainwater collection tanks.[45]

Hydro-climatological extremes play important roles in shaping and sustaining the natural environment. But when floods or droughts occur where people live and work, or where strategic assets are placed, a natural hazard becomes a potential natural disaster.[46]

Integrated Water Resource Management

In the 1980s, the concept of Integrated Water Resources Management (IWRM) was introduced to better optimize water use between different sectors, using more holistic strategies and coordinated practices. Global recognition of the potential of IWRM is reflected in SDG 6, which states: "By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate." It is thought that this goal can only be met when the current rate of implementation doubles.[47] To be most effective, IWRM activities should be carried out at the basin and aquifer level, which often requires transboundary cooperation.

Integrated Flood and Drought Strategies

Floods and droughts co-exist in many watersheds and river basins around the world. An integrated approach to simultaneously mitigate both their risk and impacts on local communities is more efficient than siloed approaches. CliMWaR, a recent UNESCO project, identified opportunities in **Chile** and **Peru** to move away from reactive crisis management towards proactive and holistic drought and flood risk management.[48] In west Africa, the Volta Flood and Drought Management project (**Benin**, **Burkina Faso**, **Côte d'Ivoire**, **Ghana**, **Mali**, and **Togo**) aims to provide the first transboundary implementation of integrated flood and drought management strategies using early warning systems for both flood forecasting and drought prediction. This will build capacities in all six basin countries for the implementation of coordinated measures to improve existing flood and drought strategies at regional, national, and local levels.[49]

Transboundary Water Allocation

The central tenet guiding extraction from international watercourses is equitable and reasonable use. Embedded in the UN Watercourses Convention, this principle is intended to help reconcile conflicting interests across international borders and to "provide the maximum benefit to each State from the uses of the waters with the minimum detriment to each".[50] Nonetheless, of the over 300 rivers that cross international boundaries, more than two-thirds do not have cooperative arrangements.[51]

Spain and **Portugal** share five rivers, with about 70% of their annual mean water resources generated in Spain, while the basin areas total 45% of the Iberian Peninsula, with nearly 65% located in Portugal. Water flows, primarily used for irrigation, are already or are becoming scarce, exacerbated by dam construction, intra-state reallocation, and extreme rainfall variations.[52] In 1998, the Convention on Cooperation for the Protection and Sustainable Use of the Waters of the Spanish-Portuguese Basins was signed to help balance environmental protection with the sustainable use of shared water resources. While it includes a sophisticated scheme for water allocation, it also stipulates that in case of drought, the Parties are exempted from compliance with the agreed flow regime.[53] Nevertheless, it is an effective model approach to the equitable sharing of surface water between states – one that builds resilience to the extreme weather events that are becoming more frequent due to climate change.

Managing a Shared Aquifer

There are very few transboundary aquifer agreements, considering that over 500 aquifers cross national boundaries. One of these governs the use of the Sag (**Saudi Arabia**) and Disi (**Jordan**) aquifer located beneath two of the world's most water-scarce countries.[54] It is a deep, non-renewable aquifer that extends hundreds of kilometers and contains water that is up to 30,000 years old. The aquifer is the most important water resource in a region with virtually no surface water and rainfall that is both low and highly variable.[55] In the 1980s, Saudi Arabia pumped water to transform the desert into a regional agricultural hub, causing a massive decline in groundwater levels. Jordan initially used the aquifer only for local water supplies, but constructed a pipeline in the 1990s to convey drinking water to Amman.[56] [57]

The solution has been the development of a transboundary agreement to lessen environmental and water stress, prevent further deterioration of the aquifer, and ease political tensions.[58] In 2015, both countries signed an agreement subject to review every 25 years.[59] It specifies the boundaries of the aquifer and stipulates different areas for conservation and use from which new water extractions would be solely for municipal needs. Most importantly, the agreement created a joint water committee, staffed by both countries and with a remit to address other water resource issues that may arise.[60]

2.1.2 FLOODS, WILDFIRES, SAND AND DUST STORMS

Droughts, floods, wildfires, and sand and dust storms are primarily influenced by land use changes and now increasingly climate change. These extreme events have become the norm, making life increasingly difficult in many parts of the world. They are also being seen as compound events whereby the cascading impacts of drought, for example, are increasing the risk and impacts of floods, creating conditions for more intense and longer wildfires, and expanding source areas for sand and dust storms.

Floods

Floods are the most damaging of natural disasters and have caused over USD 1 trillion in losses globally since 1980.[61] Growing populations, land degradation, climate change, rising sea levels, and sinking cities will likely increase the risks of and exposure to flooding events over the next few decades.[62] By 2030, the number of people annually impacted by flooding is expected to double worldwide, while property damage and economic losses will increase substantially.[63] Until recently, most flood risk management involved conventional measures, such as hard engineering or gray infrastructure. Typically, physical embankments, dams, levees, and channels were built to control flooding and mitigate its impacts. More recently, 'nature-based solutions' or 'green infrastructure' approaches have emerged as cost-efficient alternatives or complements. These solutions make use of natural processes and ecosystem processes to decrease flood risk and at the same time improve food security, water quality, carbon sequestration, and biodiversity protection,[64 65] and can be employed in river basins (e.g., reforestation, green embankments), coastal zones (e.g., mangroves, wetlands), and cities (e.g., urban parks).[66]

Peru: Sustainable Watershed Management in Glacial Mountain Ecosystems

Over the last 40 years, due to rising temperatures, the glaciated area across 18 mountain ranges in Peru has been reduced by 53%. Meltwaters from this accelerating retreat often create unstable temporary lakes, producing deadly landslides or flash floods. To counteract this threat, in 2011, a community-led multi-stakeholder coalition of scientists and public and private sector actors developed a decade-long water resources management plan to sustainably manage over 200 new lakes in the Proyecto Glaciares area. Hundreds of hectares of wetland, grassland, and forest around important springs have been protected

© UN Women_Mohammad Rakibul Hasan

and restored – tributaries were fenced off to allow natural regeneration, and communal grazing plans were put into effect. These techniques were combined with other measures, such as building dams to harvest water from periglacial lagoons and store rainwater. The implementation of early disaster warning systems has helped to reduce the risk of landslides and flash floods for more than 70,000 residents living downstream.[67]

China: Reconnecting Rivers and Wetlands

Widespread dam and dike construction in the Yangtze river basin between the 1950s and 1970s fragmented the existing river-lake wetlands system, contributing to major flooding events throughout the 1990s, which caused thousands of deaths and USD billions in direct economic losses. To mitigate future flooding risks, the Chinese government, in partnership with the World Wide Fund for Nature (WWF), reconnected the Yangtze River with lakes, and rehabilitated the natural functions of the wetland system. The project started in 2002 and has restored 448 square kilometers of wetlands, which have a floodwater retention capacity of 285 million cubic meters. In one district, the restoration of seasonal flooding increased fisheries production by over 17%. Reconnecting the river-lake wetland system has helped reduce vulnerability to flooding and increase wildlife populations.[68]

Sri Lanka: Urban Wetlands for Flood Protection

Metropolitan Colombo is surrounded by a large network of flood-retaining wetlands, both natural and managed. However, rapid recent urbanization has caused steady degradation across the network and a 30% reduction in their water-holding capacity. In 2010, the city experienced a series of record-breaking flood events that resulted in unprecedented economic losses. To reduce flood risk and future losses, from 2012 the Metro Colombo Urban Development Project designed a combination of green and gray infrastructure: wetland conservation, flood retention parks, and engineering solutions, such as concrete banks. The integration of wetlands and parks allows rainwater to infiltrate more slowly, buffering the impact of extreme events and decreasing the rate at which water moves through overtaxed infrastructure, thus providing greater flood protection and a higher quality of life for over six million people.[69] [70]

Greece: River Restoration for Flood Prevention and Water Security

The Spercheios river basin in central Greece is generally susceptible to fluvial flooding events that often exceed channel capacity, affecting most aspects of life in the area.[71] To reduce the impact of flooding, natural water retention measures employed have included restoring and stabilizing river banks, and re-meandering and widening the river bed. Two in-line water reservoirs help regulate water flows and divert any surplus to nearby irrigation networks.[72] An evaluation found that although the project area was relatively small, the measures applied led to a significant decrease in the maximum depth of flooding, maximum stream velocity, and the extent of flooded areas while contributing to long-term groundwater recharge.[73]

Mozambique: Urban Parks to Fight against Floods

The coastal city of Beira is vulnerable to both violent storms and recurrent flooding. With poorly planned settlements, low-quality housing and infrastructure, and the effects of climate change worsening, more than 300,000 residents were left vulnerable to climate-related disasters. Through the Mozambique Cities and Climate Change Project, Beira has strengthened its resilience to weather-related hazards by rehabilitating its storm water drainage system, resulting in a 70% reduction in flood risk. Upgrades include the rehabilitation or new construction of 11 kilometers of drainage canals, the installation of flood control stations, and the construction of a large water retention basin.[74] This gray infrastructure is supported by green infrastructure works,[75] which transformed the Chiveve River margins into an urban park that enhances ecosystem services (e.g., biodiversity, drainage, urban cooling, flood mitigation) as well as economic and recreational opportunities for residents.[76] Opened in December 2020, the 45,000-square-meter park serves as a buffer zone for the retention of flood water and is one of the largest urban parks in the region.[77]

Wildfires

The 21st century has seen unusually severe, frequent, and extensive wildfires. Hundreds of lives have been lost, along with huge amounts of economic damage. In many regions, climate change is increasing the likelihood of hot and dry conditions in which wildfires thrive.[78] Yet periodic burning remains essential to the health of many forests and other ecosystems, often a necessary precondition for seeds to germinate.[79] In North America, nearly 80% of native vegetation evolved with fire.[80] Indigenous peoples around the world have long used fire to manage the land, benefiting people and nature alike.[81] [82]

However, in the last century, fire suppression and exclusion practices have been imposed on fire-adapted ecosystems, creating hazardous conditions. Forests have grown denser, with an understory that can provide a ladder for flames to reach high into the canopy and produce more intense and harder to contain blazes. Additionally, a buildup of fuels on the ground due to rural depopulation, large-scale land abandonment, and the decline of nomadic practices and pastoralism has reduced fire and drought resiliency.[83] In the absence of low-intensity and frequent burns, and as natural firebreaks disappear, both human communities and wildlife are threatened by the increased risk of major fire events. Current approaches that focus primarily on fighting fires and protecting forests through vegetation thinning alone have often proven inadequate to reduce wildfire occurrence and intensity.[84]

USA: Working with Fire

Prescribed or controlled burns involve the application of fire by experts – under specified weather conditions – to restore health to ecosystems that depend on fire. Many states, such as California,[85] New Mexico,[86] Oregon,[87] [88] and others,[89] use controlled burns to complement watershed and forest restoration techniques to reduce the risk of wildfires. In Georgia, for example, restoration is conducted in tandem with prescribed burns to reduce fuel loads and improve habitat for native plant and animal species. One important species that has benefited is the longleaf pine, now found in only a fraction of its historical range in the southeastern USA. The return of pine forests provides much needed habitat for threatened or endangered species, such as the red-cockaded woodpecker, gopher tortoise, and eastern indigo snake.[90]

Portugal: Reintroducing Grazing Fire Brigades

As a result of widespread rural outmigration and associated land abandonment across Iberia and other Mediterranean basin countries, livestock numbers have plummeted, and the area of land lacking any form of grazing has significantly increased. As a result of vegetation changes, many landscapes are now more susceptible to wildfire, especially as longer and hotter summers become more common.[91] Rewilding efforts in the Greater Côa Valley in northern Portugal demonstrates how grazing by large, free-roaming herds of herbivores, such as horses and wild cattle, can be a low-impact, cost-effective way of controlling wildfire and boosting biodiversity.[92] These 'grazing fire brigades' consume vegetation that would otherwise accumulate as fuel for wildfires.[93] Since 2006, a self-sustaining population of around 45 Garrano horses have been released into the 1,000 hectare Faia Brava Reserve and have already reduced the incidence of wildfire.[94]

Indonesia/Russia: Fire Prevention through Peatland Restoration

Dry peatland areas are susceptible to wildfires and the resulting smoke and smog cause human respiratory and cardiovascular problems. Effective rewetting of the peatland ecosystems offers fire prevention and is a key climate mitigation measure that reduces emissions from peatland oxidation and fires. Globally, rewetting and restoring peatlands can significantly enhance drought resilience and lower the risk of wildfires. By reducing smog, restored peatlands can also reduce the associated health and economic impacts.[95] In the Sebangau National Park in Kalimantan, Indonesia – home to 20% of the world's orangutan population – measures to restore the forests and rewet peatlands have helped prevent the spread of wildfires. By reducing logging and removing drainage canals to rewet the peat, the incidence and intensity of fires in the park have been significantly reduced compared to its surrounding area.[96]

In the Moscow region of Russia, a major peatland restoration project was initiated in response to extensive peat fires that occurred during the summer of 2010. The project, which runs to 2023, aims to ensure at least 590 square kilometers of degraded bogs are restored and sustainably managed, with plans for rewetting a further 450 square kilometers. The project will also monitor greenhouse gas emissions and biodiversity to expand local scientific and technical competence. To date, over 180 square kilometers of peatland have been rewetted, reducing the fire hazard rating over 950 square kilometers.[97]


© CAL FIRE_Official

Australia: Cultural Burning Practices

In **Australia**, flora and fauna have evolved to co-exist and thrive under a seasonally high risk of wildfires. Prior to colonization, for at least 50,000 years, Aboriginal peoples used fire as a management tool to facilitate hunting, alter vegetation patterns, and regenerate the bush. These cultural burning practices were slowly eradicated as colonization extended its reach across the continent from the 1700s.[98] Since then, the Australian bush has seen dramatic falls in biodiversity, widespread tree and shrub encroachment on grasslands, and more frequent and destructive bushfires.[99] [100] Since cultural burning was reintroduced on a large scale in 2005, the area of land destroyed by wildfires has more than halved, from 265,000 square kilometers in 2000 to 115,000 square kilometers in 2019.[101] The tropical savannas of northern Australia have benefited greatly from the reintroduction of a traditional fire management regime,[102] which over the last seven years has led to a reduction in greenhouse gas emissions of more than seven million tonnes of carbon dioxide equivalent.[103]

Sand and Dust Storms

Sand and dust storms (SDS) are common in arid and semi-arid regions. They typically occur when strong winds lift sand and dust from bare, dry soils into the atmosphere, which can often transport particles hundreds or thousands of kilometers.[104] SDS events are given many local names: examples include the sirocco, haboob, yellow dust, white storms, or the harmattan. They are natural seasonal phenomena exacerbated by poor land and water management, droughts, and climate change.[105] The combination of strong winds and airborne mineral dust particles and pollutants can have significant impacts on human health and societies. Fluctuations in their intensity, magnitude, or duration can make SDS events unpredictable and dangerous. Source and impact mitigation activities are part of a comprehensive approach to managing the risks posed by SDS, from local to regional and global scales. Local communities in source areas are directly affected and will need to take very different actions to those being impacted thousands of kilometers away. Stakeholder participation, underpinned by up-to-date scientific knowledge, is vital for effective SDS decision-making and policy.

Iraq, China, and Kuwait: Land Restoration for SDS Source Mitigation

The Middle East and China are largely arid and susceptible to SDS. Iraq has prioritized efforts to address SDS in its national development agenda. This includes sand dune fixation as part of its Land Degradation Neutrality (LDN) targets, recognizing that SDS events are a prominent threat to sustainable land management and food production. Working with national and international partners, Iraq has successfully transformed over 3,000 square kilometers of formerly barren land into productive agricultural land.[106]

The Beijing-Tianjin Sandstorm Source Control Project in China includes a mix of land restoration measures, such as reforestation, sustainable grassland management, water and soil conservation, and sand fixation.[107] The number of sandstorm occurrences in Beijing has decreased from an average of 13 times annually at the beginning of the project to two to three times in recent years. The project has also increased local incomes by promoting the cultivation of medicinal herbs and developing a forest-related economy.[108]

In Kuwait, native plants were successfully employed to limit wind-driven sand movement in the Liyah protected area, and green belts of moringa were used effectively in the Kabd area. These salt-tolerant, native plants fix sand, reducing transport rates and dust concentrations. They also capture windblown sediments from distant sources, reducing sand accumulation around human settlements.[109]

Burkina Faso: SDS Early Warning System

Burkina Faso suffers from frequent SDS emanating from the Sahara Desert during its dry season. Airborne dust poses significant health issues for vulnerable population groups, such as children, pregnant women, the sick or the elderly, including pulmonary and cardiovascular diseases and meningococcal meningitis. The Burkina Faso National Meteorological Agency is working with the State Meteorological Agency of Spain and the Barcelona Supercomputing Center to provide SDS early warning advisory information in color-coded maps that indicate the risk of SDS events within 48 hours.[110]

Central Asia: Fighting SDS with Regional Cooperation

Mismanagement of land resources, such as soil or water, can worsen SDS. In Central Asia, the well-known desiccation of the Aral Sea by extensive and long-term water extraction for irrigation has caused many negative environmental and socio-economic consequences: high salinity of the remaining waters, the collapse of productive fisheries, the degradation of six million hectares of agricultural land, and overall loss of native vegetation.[111] In addition, the now-exposed dried bed of the Aral Sea (now called the Aralkum desert) disperses millions of tonnes of toxic salty dust into surrounding areas by wind transport.[112] Five countries – **Kazakhstan**, **Kyrgyzstan**, **Tajikistan**, **Turkmenistan**, and **Uzbekistan** – have joined up to tackle SDS through the UNCCD-funded project 'Regional approaches to combat drought, sand and dust storms in Central Asia'. It supports countries to develop national and regional SDS plans and strategies that engage diverse stakeholders, including government agencies, academia, practitioners, and local communities. With a comprehensive SDS and drought risk reduction strategy in place, including monitoring and early warning systems, these Central Asian countries are now able to enhance their preparedness and resilience by focusing on pre-impact governance, in line with national disaster risk reduction and mitigation as well as sustainable land and water management plans.[113]

© China Foto Press / Barcroft Media

2.2.1 LAND GOVERNANCE AND TENURE SECURITY

Land governance determines how people acquire rights to use and control land and its resources.[114] At the heart of responsible and equitable governance is a recognition of legitimate land rights, including those of women and youth, indigenous peoples, and local communities. Land inequality is increasing,[115] while the per capita availability of farmland is decreasing.[116] Transboundary and national large-scale land acquisitions linked to global supply chains can worsen inequalities and dispossession. Tenure – the laws, customs or traditions that govern land use – is vital to the success of many restoration activities as both a right and responsibility associated with the control of a plot of land or a natural resource. Tenure security is seen as both an enabler and an objective of land restoration and is often an essential first step towards achieving LDN.

Weak governance undermines sustainability and justice while inequalities in land distribution contribute to increased pressures on scarce land and natural resources.

In 2012, the Committee on World Food Security adopted the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security (VGGT).[117] Its agreement was recognized as a global call to improve and more equitably manage the linkages between natural resource governance and food security. At UNCCD's Conference of the Parties in 2019, a landmark decision was adopted, inviting the 196 Parties to the Convention to review and, where appropriate, adopt national land governance legislation and procedures to support land restoration. The decision further encouraged countries to recognize legitimate tenure rights, including customary rights, consistent with national legal frameworks, as well as enhance women's equal access to land and land tenure security.[118]

Integrating VGGT and LDN

While the goal of LDN is to maintain or enhance the health and productivity of land-based natural capital, the focus on people's relationship to land is embedded in all LDN initiatives, which seek to reinforce the responsible and inclusive governance of land resources.[119] One key governance issue is a need for the robust protection of legitimate land tenure rights to ensure that vulnerable people are not disadvantaged by land use decisions and restoration efforts. The FAO/UNCCD Technical Guide on integrating VGGT and LDN is designed for policy and decision makers to increase their awareness of the potential means by which legitimate rights and more responsible governance of tenure can contribute to the success of LDN targets and other land restoration commitments. Ultimately, it aims to enhance country-level implementation so that no person, group, or community is left behind.[120]

The VGGT principles include human rights, non-discrimination, equity and justice, gender equality, sustainability, consultation and participation, the rule of law, and transparency.[121] As outlined in the technical guide, universal pathways to enhance secure land tenure and effective restoration involve legal, policy, and administrative frameworks as well as multi-stakeholder platforms and dispute resolution mechanisms. Context-specific pathways, mechanisms, and processes may include integrated land use planning, land consolidation, and other land administration tools.

In its many forms, tenure is part and parcel of all land use activities. Participatory governance and tenure security are key elements to be embedded in the design, implementation, and outcomes of land restoration interventions. When land tenure and restoration are considered in tandem, they can strengthen the link between natural resource governance and sustainable land and water management practices. Many land restoration activities require flexible, decentralized governance that can accommodate new knowledge types and skillsets as well as the values, relationships, and engagement of multiple actors.

There are numerous types of legitimate tenure – state, individual, or group rights; property ownership, public and private leases; and customary, traditional, or indigenous arrangements – and all of which determine the level of investment in land restoration.

TABLE 2.1 Country examples of links between land tenure and land restoration

COUNTRY	TENURE CONTEXT	RESTORATION ACTIVITIES
Cameroon[122]	An overly complex governance framework with numerous overlapping legal systems has contributed to deforestation for charcoal production on state-owned land. As a result, increased levels of conflict between customary rights landholders have occurred.	The Restoration Opportunity Assessment Methodology[123] was used to identify high-priority locations for sustainable charcoal production near protected areas. Land user rights were recognized by the government and linked to the regulation of their forest tenure arrangements. Land restoration using bamboo and other native plants was promoted for environmental and economic benefits.
China[124]	Land ownership is vested in the state. De-collectivization and reallocation of land to households and individuals is now occurring.	The implementation of annual forest management and restoration plans includes the provision of leases of up to 70 years for household land and allocated forest plots.
Myanmar[125]	Tenure insecurity and land dispossession are primarily due to ethnic conflict and violence, leading to illegal forest exploitation.	Sub-national level land use planning with new tenure rules was used in the design of restoration initiatives.
Pakistan[126]	Land and ecosystem degradation has resulted from a lack of clear tenure legislation and governance.	Implementation and monitoring of restoration and value chain development at the community level with restrictions imposed on land grabbing. Promotion of ecosystem management by community-led committees.

Lessons Learned from the VGGT

The VGGT multi-stakeholder platforms bring together civil society, government, academia, and the private sector to plan and implement common visions on land governance that are based on international good practice. The resulting capacity development and awareness raising has had some successes. For example, in some cases, it has led to a recognition of customary and women's land rights, the creation of dispute resolution mechanisms, and the mapping and recording of land rights.[127 128 129] Although implementing programs to improve the security of community property rights is gaining importance, more concrete actions are needed.[130 131 132] This has specific implications for land restoration because access and control largely influence investments and activities to avoid, reduce, and reverse land degradation.[133 134] Here are a few examples that demonstrate key lessons learned in VGGT implementation, focusing specifically on the connection between secure tenure and land restoration.

Senegal River Basin

With 110 million hectares of pasture and 1.2 million of arable land, the Senegal river basin contributes significantly to West African agricultural production and food security. Some of the most intractable obstacles to investing in nature-positive food production in the river basin relate to issues of tenure and resource rights.[135] As a result, multi-stakeholder VGGT platforms have been developed, establishing and consolidating regional, national, and local participatory dialogues on land tenure. This has allowed the Senegal River Development Organization to initiate the preparation of a basin-wide land charter that includes transboundary governance arrangements.[136]

- **Senegal.** The multi-stakeholder platform involves 22 local authorities, decentralized government structures, and civil society. It has established 10 local commissions and supports land tenure regularization for women and youth. The platform examines land issues, including agro-industrial development, environmental degradation, negotiation and conflict resolution, to prevent land-related disputes or avoid their escalation.

- **Mali.** A new Agricultural Land Law includes VGGT elements. For example, it mandates that 15% of arable land (both irrigated and rain-fed) must be allocated to women and youth organizations. In some cases, certificates of ownership are provided for agricultural land managed by local communities. In other cases, customary and land possession certificates recognize individual and collective tenure rights which can be inherited, traded, or used as collateral for loans.
- **Mauritania.** Before the creation of multi-stakeholder policy dialogues, violent social conflicts often contributed to failures in major public and private hydro-agricultural development schemes. The dialogues have provided a safe place to recognize and enforce legitimate land rights of the most vulnerable, particularly women and youth. They have demonstrated the fundamental role that land rights can play in ensuring food and nutrition security and creating meaningful jobs for rural youth.

Community-based Forestry

Governments are increasingly giving legal recognition to commercially driven, community rights to timber and non-timber forest products. FAO assessments show that community forest tenure reform in 14 countries has been effective in reducing deforestation, illegal logging, wildlife poaching, wildfires, agricultural encroachment, land grabs, and the over-exploitation of forest resources. However, these community-based rights are often less robust than those held by companies and smallholders due to fewer legal protections, higher barriers to resource use, inadequate access to justice, and the lack of administrative support in documenting rights.[137]

- **Grenada, Saint Lucia, and Saint Vincent and the Grenadines.** For these small island developing states, land banking has been used as an instrument to address land abandonment and degradation. This involves reforming the land administration system and the management of state-owned lands. A pilot land bank was established to build capacities and offer leases to the landless and tenure insecure, including women and youth. Leases were then matched with sustainable land management project commitments.[138]
- **Sierra Leone.** The country has a multi-stakeholder platform and a National Land Policy that incorporates the full set of VGGT principles. With input from civil society, a massive awareness-raising campaign was undertaken to consult local communities and develop a shared vision for a culture of forest preservation. A new forestry law is being drafted, and pilot projects have mapped and recorded legitimate land rights held by local communities and women. Cost-effective, customizable, and user-friendly technologies help adjudicate and define boundaries, based on the participatory validation and issuance of cadastral maps.[139]
- **Tunisia.** To protect fertile agricultural land and contribute to LDN, land consolidation aims to reduce fragmentation and increase average farm size. Owners with dispersed parcels of land can exchange them within limits – by aggregating small plots, land becomes more economically viable. These larger parcels are more conducive to investments in contour plantings targeted to the reduction of soil erosion and water conservation. The consolidation process includes awareness raising on economic impacts, peer-to-peer learning, participatory and gender-inclusive approaches, and involves farmers' associations, public authorities, and civil society.[140]

2.2.2 INTEGRATED LAND USE PLANNING

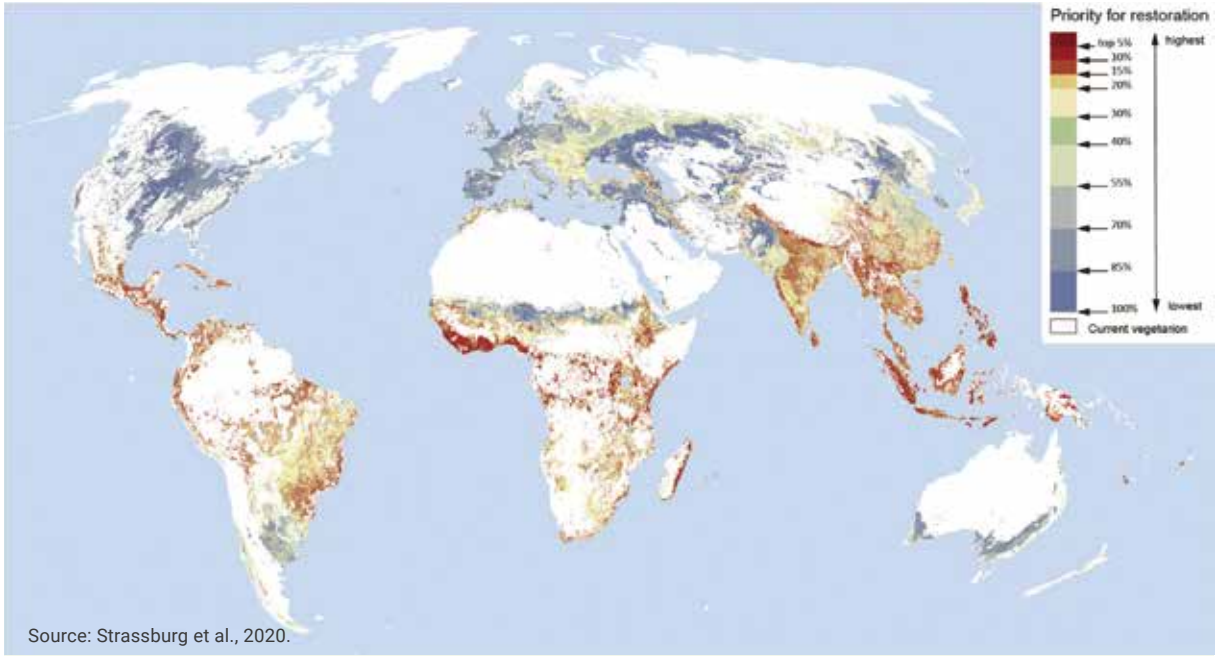
Integrated land use planning is an effective administrative tool to address land degradation at multiple scales. Its purpose is to identify, within a given landscape, the best combination of land uses to meet the needs of stakeholders while safeguarding the health of land resources for future generations. More balanced and efficient land allocation within a region, watershed, or district, considering the different uses needed, can help pinpoint areas for land restoration and improve ecological connectivity.[141] As a contribution to global and national restoration targets, including LDN, integrated land use planning seeks to balance environmental sustainability with the economic development opportunities for restoring land-based natural capital. However, success requires wide-ranging coordination of planning and management across different sectors concerned within an administrative or geographical area.

Integrated land use planning can also serve as an effective means of securing tenure by providing an enabling framework for the legitimate recognition of land and resource rights.[142] A human rights-based approach to spatial planning sees individuals and communities as rights holders, and the state as a duty bearer committed to uphold these rights.[143] For many rural poor, the implementation of this approach confers legal and social entitlement and the freedom to make decisions on what, where, and how to use land resources to improve their livelihoods.[144] Managing competing land uses (i.e., negotiating trade-offs) requires policy and institutional diligence to ensure that efforts to achieve development priorities do not harm environmental integrity, but rather contribute to land restoration, food and tenure security, and poverty reduction.

Global Restoration Hotspots

Identifying landscapes where restoration benefits can be maximized will deliver the most cost-efficient restoration outcomes, i.e., those with the greatest returns on the investment of time, money, and effort. Prioritizing global restoration hotspots across all terrestrial biomes, including estimates of benefits and costs, can support better implementation and financing of the land restoration agenda.

FIGURE 2.2 Global restoration hotspots (2020)



Source: Strassburg et al., 2020.

A global analysis of priority areas for restoration based on ecoregions has only recently become available. Some countries have more to contribute to the protection and restoration of global public goods than others, and international cooperation will be key to their success. For example, restoring 15% of converted or degraded lands in priority areas could avoid 60% of expected species extinctions, while sequestering up to 300 gigatonnes of carbon – this represents some 30% of the total increase in the atmosphere since the Industrial Revolution. The cost-effectiveness of restoration can increase 13-fold when spatial allocation is optimized using a multicriteria approach (e.g., biodiversity, climate, water variables), reinforcing the importance of integrated land use planning.[145 146]

Considerable gaps remain in linking global priority restoration hotspots to national land use planning as well as to the international finance required. Planning in many countries continues to be applied piecemeal through land use controls embedded in local land administration systems. The environmental planning, land tenure, and their administrative sectors still tend to operate in silos, limiting their ability to deliver meaningful restoration outcomes at scale.[147] [148]

Greater Mekong Subregion: Optimizing Investments based on Multi-Criteria Assessments

Since 2005, the Greater Mekong Subregion (GMS) Core Environment Program, administered by the Asian Development Bank, has contributed to better land governance in Cambodia, China, Laos, Myanmar, Thailand, and Vietnam – all countries with substantial land degradation. The program focuses on integrated land use planning to direct USD 50 billion worth of investments. Land use change models are used to translate different land demand scenarios into future land use maps. The GMS Regional Investment Framework (2013-2022) supports strategic, multi-criteria environmental assessments to identify development scenarios that optimize trade-offs between economic opportunities, environmental impacts, and mitigation costs.[149] Assessments were employed in:

- the development of a Strategy and Action Plan for the **Greater Mekong Subregion North-South Economic Corridor** to balance environment and social protection with economic opportunities when planning transport infrastructure.
- **Vietnam** to monitor and evaluate the protection of forest watersheds that contribute to hydropower production. The assessed levels of protection determined and triggered payments to local communes to provide ecosystem services, with over 500,000 rural people now employed as custodians of important forest watersheds.
- **Cambodia** to produce a plan for Integrated Water Resource Management of the Tonle Sap Basin.
- **Laos** to identify areas complying with environmental and social safeguards for rubber plantations.

USA: Integrated Land Use Planning at Local and State Levels

In the state of Oregon, the Department of Land Conservation and Development (DLCD) works in partnership with local governments to address diverse land needs and provide policy direction for state land use planning.[150] Its guiding principles include a healthy environment, a prosperous economy, a better quality of life, and greater equity. As local authorities rarely have sufficient capacity, DLCD has created detailed datasets, maps, and web tools to help map socio-economic considerations and environmental features, such as estuaries, wetlands, forests, flood hazards, and limited groundwater areas. This information can then be linked to conventional land use planning information at a parcel level, across commercial and residential uses, public lands, administrative boundaries, and city zones. User-friendly online GIS packages incorporate satellite and drone/aerial imagery to produce background maps and inform decision-making at the local and state level.[151]

Guyana: Linking Restoration to Land Administration

The Guyana Land and Surveys Commission Act of 1999 mandates the state "to have charge of and act as guardian over (all) public lands, rivers, and creeks". FAO is supporting the government through a sustainable land management project to achieve its goals for land use planning and development, reclamation, combating land degradation, and scaling up sustainable land management. These activities are linked to national strategies, including a Low Carbon Development Strategy, a framework for Reducing Emissions from Deforestation and Degradation (REDD+), and voluntary LDN targets. The project, which started in 2018, seeks to address policy, institutions, governance, and capacity development and strengthen land administration and land use planning systems.[152]


© John Hogg_World Bank

Strengthening Urban-Rural Linkages

Urban sprawl impacts peri-urban and rural areas, many of which are important for regional and local food and water security and other important ecosystem services. Responsible land governance and the wise use of regulations, including landscape and territorial planning, together with forms of land sharing and areas set aside for conservation and restoration, can help strengthen urban-rural linkages that contribute to human and economic security.[153] [154]

Botswana: Participatory Planning to Manage Urban Sprawl

Tlokweng is a commuter town situated in a rural customary tenure area outside Gaborone, the rapidly growing capital of Botswana. Three scenarios were considered in the formulation of the Tlokweng Development Plan (2015-2039) to compare different growth models, and best determine how to balance the preservation of cultural and environmental assets of peri-urban and rural villages with economic and social opportunities generated by adjacent urbanization. The three scenarios – resilient growth development, compact development, and outward or sprawling development – were evaluated using a multi-criteria GIS framework against a set of performance criteria, including metrics of biodiversity and cultural heritage, health and food access, and economic growth. As a result of this analysis as well as insights from participatory community engagement, the first scenario was chosen as a framework to 2025 to map urban-rural linkages and bring together social, economic, and environmental dimensions. With continued rapid economic and population growth supported by government investments in infrastructure such as roads, the Tlokweng Development Plan now forms an integrated planning approach to benefit current and future households, smallholders, and small settlements in the urban-rural interface.[155]

Colombia: Territorial Governance

In Colombia, the POT Modernos Program (Modern Land Use Plans) incorporates comprehensive territorial development in land use planning processes, which aim to strengthen urban-rural linkages and address social inequalities and a need for territorial governance. The program integrates national and municipal planning processes into a unified prospective plan. A regional vision overcomes the political and administrative constraints that traditionally governed the local planning process. Environmental and risk management thinking underpins the allocation of land rights to make land use planning more effective and integrative. It also encourages collaborative governance and incorporates a conflict resolution framework. The cost for the first phase (2016-2018) was USD 45 million, with a portion funded by a World Bank loan.[156]

Ethiopia and Kenya: Land Use Scenarios for Policymaking

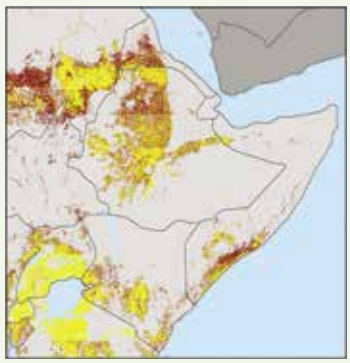
In addition to the global scenarios produced for this Outlook, PBL, UNDP, EC-JRC, and Wageningen University jointly carried out a regional analysis on East Africa to build capacity for national level policymaking to increase sustainable land use and management.[157] This pilot study informed government officials and relevant stakeholders on recent land degradation trends over the past 10-15 years as well as the impacts of projected changes in land use and management up to 2050. Adapting a global scenario approach to the national level allows decision-makers to better manage trade-offs and identify priorities to achieve development goals, today and in the future. Using a Shared Socioeconomic Pathways (SSP) model, three scenarios were projected forward to 2050: SSP1 (Sustainability or Green Road), SSP2 (Middle of the Road), and SSP3 (Fragmentation or Rocky Road).

Ethiopia and Kenya have each developed targets and plans to address land degradation. These relate primarily to population growth, increasing agricultural productivity, and the prevention of forest loss. Ethiopia currently spends more than 10% of its annual budget on agriculture, while one of Kenya's 'Four Big' priorities is 100% food and nutrition security. The key findings were benchmarked against current policies and development strategies as well as future planning in both countries. Its main conclusions found that:

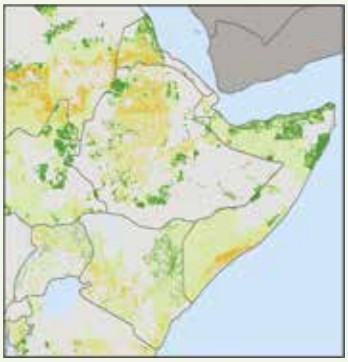
1. While national goals and targets on land use, management, and restoration generally align with SSP1 and SSP2, rapid population growth and declining productivity in agriculture and natural ecosystems line up with SSP3. In both countries, current trends in ecosystem conversion are likely to continue, pointing to a Rocky Road (SSP3) ahead. In Ethiopia, SSP3 implies a near doubling of cropland, leading to the conversion of 75% of the remaining forest. In Kenya, the conversion will be much smaller only because there is less forest initially.
2. Actual trajectories for Ethiopia and Kenya are aligned with SSP2 and SSP3 rather than SSP1. Ethiopia is a low-income country with a per capita GDP of USD 856 in 2019. Continued population growth in line with the pessimistic scenario (SSP3) will lead to a modest increase in per capita GDP to USD 1,210-2,300: likely significantly less than the USD 2,250 projected for the middle-of-the-road scenario (SSP2). Kenya's Vision 2030 Plan strives to transform the country into an upper middle-income economy by 2030. However, population growth rates exceeding the government's annual growth rate target of 2.4% remains a major impediment.
3. The land-related challenges facing Ethiopia and Kenya are well recognized in the policy responses developed so far. The gap between policy ambitions and actual trends means that while laudable goals exist, implementation will be key. This will require capacity development, institutional coordination, enhanced extension services, and funding to bridge gaps. In Ethiopia, the government has demonstrated strong leadership in boosting food security, but is often limited by capacity constraints. In Kenya, land use policy is devolved to counties, yet many lack the necessary expertise or access to funding.

FIGURE 2.3 **Map with projected changes in cropland and grazing area (SSP2), 2015–2050**

Change in cropland in East Africa under the SSP2 scenario



Change in rangeland in East Africa under the SSP2 scenario



Legend Cropland in 2015 | No cropland | Water bodies | Expansion in 2050 | Outside region

Legend Rangeland in 2015 | No rangeland | Water bodies | Expansion in 2050 | Outside region | Rangeland to cropland in 2050

Source: 2015 data based on (European Space Agency (ESA), 2017) projections based on the MAGNET model allocated with GLOBIO (Schipper, Hilbers et al., 2020)

2.2.3 GENDER-RESPONSIVE LAND RESTORATION

The UN Decade on Ecosystem Restoration (2021-2030) frames restoration as a momentous nature-based solution for achieving many of the economic, social, and environmental goals and targets agreed to in the 2030 Agenda for Sustainable Development. Yet a critical void lies at the heart of this agenda, namely a lack of attention to the social and political dimensions of land restoration initiatives.[158] Evidence shows, for example, that conservation and restoration projects and programs that integrate gender dimensions remain the exception rather than the rule.[159 160]

In fact, many historical gender-blind restoration initiatives – including Reducing Emissions from Deforestation and Forest Degradation (REDD+) interventions – have contributed to even greater gender inequalities, with women's access to land and natural resources further restricted, women's voices and agendas undermined, and their work burden increased.[161 162] Nevertheless, designing and implementing gender-responsive restoration initiatives can build on approaches and experiences from around the world, such as lessons learned from REDD+ implementation,[163 164] the framework approach for gender-responsive forest landscape restoration,[165 166] and the UNCCD's guidelines for gender-responsive LDN transformative projects and programmes.[167]

© treeaid_org_uk

Mali: Gender Empowerment through Community Forest Management

Between 1990 and 2015, Mali lost one-third of its forests, nearly 20,000 square kilometers. The Duwa and Sutebwo forests in the Ségou region have been severely degraded by unsustainable tree felling, overgrazing, and agricultural expansion. Local communities depend heavily on tree resources for food, fuel, and income – drought and more frequent bushfires have made livelihoods even more precarious. Tree Aid's three-year project Strengthening Malian Forest Management (2017-2020) worked with 2,672 households in 41 rural communities, across six communes. Its main aim was to catalyze collaborations to protect and restore forest biodiversity by improving natural resource management, balancing community food, energy, and economic needs and delivering improved access rights for women and youth.[168] Over 200 square kilometers of forest are now managed under community forest management plans, increasing incomes three-fold mostly through small businesses based on the harvesting, processing, and trading of non-timber forest products, mainly honey and shea butter. Shea butter is typically produced by women in low-income households, who reported a moderate to equal ability to choose how to spend their own income.[169]

Nicaragua: Overcoming Barriers to Access

Rural women in Nicaragua face multiple barriers to controlling and accessing land. The NGO Trócaire and its local partner organizations developed a series of capacity building interventions to overcome barriers around land purchase, registration, leasing, sharecropping, and inheritance, including raising awareness and developing women's capacity to demand and exercise their land rights. Measures to increase access to finance, inputs, and other services confirmed that women with improved access to land and water resources benefit from improved livelihoods. This empowerment of women increased their self-esteem and community status. The project also highlighted two other key enablers of success: the importance of working with men to overcome male chauvinism and engaging with rural organizations and extension services to increase the uptake of agroecological practices.[170]

Uganda: Women Empowerment through Adaptive Collaborative Management

In the Mpigi, Rakai, and Masaka districts of central Uganda, a 2011 gender-responsive forest restoration project, called Gender, Tenure and Community Forestry, successfully challenged gender, tenure, and leadership norms.[171] The aim was to enhance women's involvement in forest management and promote equitable benefit sharing. Following an Adaptive Collaborative Management approach, stakeholders developed a shared vision and implementation plan that included evaluation and adaptive management protocols. Women were given leadership roles in restoration decision-making and supported within mixed-gender project groups, so that their capabilities and successes were spotlighted to their husbands and male villagers. During the project, the number of women owning woodlots increased from 5 to 32.[172] In addition to more equitable benefit sharing, women have taken the lead in other spheres – for the first time in the region, they have stood for, and been elected to community and local government leadership roles.

Niger: Initiative for Women and Land

The Initiative for Women and Land (Initiative Femmes et Terroirs – IFETE) was set up in 2011 to address the defeminization of agriculture (reduced women's participation) in the densely populated Maradi region of Niger.[173] One of the activities supported over four years was the development of a social enterprise, managed and administered by women, to restore degraded pasture in the community of Tambaraoua. Women formed a community management committee, comprised of both sexes, to oversee the clearing of invasive weeds, reseeding with locally available grass species for fodder, and planting of 30,000 seedlings to produce gum Arabic. They brought 10 years of experience in managing savings groups to succeed in these income-generating activities, employing men, women, and youth while establishing a village surveillance committee to guard against illegal grazing or cutting. This women-led enterprise continues to operate independently, generating revenue from fodder and gum production while improving biodiversity values.

Jordan: Shifting Gender Norms in Culturally Sensitive Ways

In Jordan and other countries, where cultural norms typically bar women from membership in formal groups, sensitizing the communities to consider the benefits of gender responsiveness can help overcome traditional barriers. In 2010, a government initiative, supported by NGOs and funded by IUCN, granted four Bedouin communities exclusive land rights to restore degraded rangelands in Bani-Hashem using the hima system – a traditional rangeland management system similar to community-based natural resource management. These rangelands were traditionally managed by a pasture association that excluded women, who were not allowed to work outside their homes. The Arab Women's Organization (AWO) led a culturally sensitive initiative to raise awareness about the benefits of including women in pasture management under the hima system, and trained women in relevant skills and management practices. Working with tribal leaders and respected woman elders helped shift attitudes to achieve a donor goal of 40% of the pasture management body being women. New collective enterprises for women set up by the AWO gave them the confidence to voice their views, and empowered them to participate fully in hima management, as well as generate income through herbal tea production, aided by a donor-funded drying and packaging unit.[174]

Zambia: Gender Integration in REDD+ Strategies

In Zambia, the Nyimba Forest Project was designed to support a national REDD+ Readiness Program and provide recommendations for a broader REDD+ strategy.[175] The project (2010-2014) placed a premium on the inclusion of gender considerations to capture women's knowledge and experience, improve the future distribution of benefits, and deliver more balanced and inclusive activities. In addition to capacity building workshops and seminars focused on gender integration, the project engaged women in research and decision-making. These strategies helped achieve a gender ratio of 53 women to 47 men participating in 51 community meetings and study activities, and 26 women assuming decision-making positions over the duration of the project. The project generated guidelines to better integrate gender issues in REDD+ strategies and programs at the national level.

Côte d'Ivoire: Strengthening Women's Land Rights

In Côte d'Ivoire, women typically have very limited access to property ownership and generally have less secure land tenure than men. In 2020, the World Bank's Gender Innovation Lab reported on factors encouraging the uptake of three different interventions to strengthen women's property rights in rural Côte d'Ivoire, in partnership with the government's Agence Foncière Rurale:

- a video setting out the benefits for men of certifying one plot of their land in their wife's name – shifting land ownership allocation within a household
- registering men in a lottery to win an expensive three-wheeled motorcycle if a domestic land allocation transfer is documented
- a cost reduction for couples to formalize a customary marriage by a civil process, making marriages subject to recent legal reforms that strengthen women's rights

Results of this pilot suggest that highlighting the benefits of women's land ownership, regardless of incentives, can encourage men to reallocate land to their wives. Uptake was highest among participants in the lottery incentive with 75% acceptance, slightly lower for the video screening at 65%, and lowest at 44% for those offered support for civil marriage.[176]

© Kong Solina_Feed the Future

2.2.4 **YOUTH ENGAGEMENT**

Half of the world's population are children and youth, and they are often the first and most affected by the impacts of desertification, land degradation, and drought. Engaging with youth as key stakeholders and agents of change may be difficult but is vital. The implementation of the land restoration agenda now will positively influence the trajectory of societies in the decades to come and thus have a direct impact on young people's lives. There is an urgent need to strengthen the appeal of agriculture and food systems to young people to secure a healthy environmental legacy for future generations. There are huge potential returns on investing in young people to deliver on food security, poverty reduction and employment generation as well as peace and political stability.[177]

Grenada: Goat Dairy Farm

In the Caribbean, the Grenada Goat Dairy Project promotes fun and educational activities so that youth can learn about agriculture and livestock farming and gain practical experience that may lead to a future livelihood. The project was launched in 2007 with a particular focus on students and young workers and seeks to encourage and maintain the cultural dignity and value of small, independent family farms that produce high-quality meat and dairy for local markets.[178] The project partnered with St. Patrick's Anglican Public School to create a youth education dairy facility – combining traditional classroom activities with hands on work experience. As a fully functioning goat farm, complete with milk production capacity, it also incorporates a school garden, poultry coop, composting area, and outdoor classroom. Students assume all animal care responsibilities, grow vegetables, make compost, and keep records. They also produce instructional manuals and videos, shared by both traditional and social media campaigns.[179] [180] This community-wide project continues to expand to additional schools, creating opportunities for other children and young adults in the surrounding region.[181]

Morocco: Rural Mobile Employment Centers

Promoting employment for rural youth is a key priority for the Moroccan government. Even with strong economic growth, few rural jobs are being created – in the second quarter of 2021, the youth unemployment rate was about 30%.[182] Nor do national figures accurately capture a significant rural issue: underemployed and informally employed youth workers. Promoting Youth Employment in Rural Areas in Morocco (*Promotion de l'Emploi des Jeunes en Milieu Rural*) was a five-year German-funded project (2015-2020) to improve the employment situation for 5,000 young rural women and men in nine different provinces in the Fès-Meknès and Béni Mellal-Khénifra regions. The project used several approaches in parallel:

- National-local cooperation: the national employment service partnered with local civil society organizations to open rural employment centers. Local youth were trained to become employment advisers to their peers and travelled across their region to inform youth about and train them for available jobs.
- Local employment committees: these included individuals from local authorities, civil society, and the private sector to initiate multi-stakeholder dialogues at the local level.
- Institutionalization: national and regional decision-makers were engaged by local committees to create appropriate institutions based on joint steering and financing mechanisms, including full-service mobile employment centers to serve rural populations.

By 2019, 4,200 youth, including 1,600 young women, had been trained or coached in one of the four mobile employment centers. A bottom-up approach – as well as alignment with national institutions, and the inclusion of local civil society organizations – was seen as critical to the project's success. In 2017, for example, nearly half of the youth reached had started work, and the proportion in formal employment had doubled to over 40%.[183]

Nigeria: Agribusiness Training

Nigeria is the most populous country in Africa with high rates of youth unemployment, especially in rural areas and among women. The Pro-Poor Growth and Promotion of Employment program is an innovative public-private partnership between the Sustainable Development Goals Fund,[184] [185] United Nations agencies, the Sahara Group, national and state governments, and the world-renowned Spanish chefs, the Roca brothers.[186]

Testing the model with an initial phase (2018-2019) in Kaduna State, the program promoted sustainable agri-food value chain development, food and nutrition security, youth employment, and poverty alleviation.[187] This pilot helped reduce post-harvest losses by facilitating access to new markets and the establishment of a processing facility. Farmers were connected to micro, small, and medium enterprises, strengthening local business engagement and further developing value chains. To take advantage of new markets and off-farm opportunities, farmers, distributors, and processors were all supported to improve their management skills and knowledge of financial services. The pilot reached 246 farmers and 15 cooperatives and farmers' groups, which developed business plans to transform their small-scale farms into larger and more profitable agri-business enterprises.

Haiti: The Garden that Turned a 'Red' Zone Green

In 2012, the Jaden Tap Tap (Garden Tap Tap) project transformed a former rubbish dump into a productive community market garden. The project is part of the agronomy program of SAKALA (Sant Kominote Altènatif Ak Lapè) or 'the community center for peaceful alternatives' located in Haiti's notorious Cité Soleil.[195] Initially, Jaden Tap Tap was a source of food for neighborhood youth and residents of the nearby elderly and disabled persons displacement camp. As well as vegetables, the community planted moringa trees, a fast-growing species, to help feed local families.

SAKALA also began education programs to match the farming expertise of elderly people living in the camp with local youth[196] – it selected 250 at-risk children to teach them the basics of agroecology, agroforestry, nutrition, as well as leadership and entrepreneurial skills. With additional support, from 2017 SAKALA trained 100 young adults as agricultural entrepreneurs. The trainees were selected based on their vulnerability, and included young parents, former prisoners, and gang members. Altogether trainees have created 20 businesses in food production, beekeeping, and composting. Today, Jaden Tap Tap is a vibrant and productive living classroom, providing youth with a safe, positive environment and employing at-risk young adults with few other economic opportunities.[197]

Samoa: A Farm to Table Value Chain Approach

Samoa is a small island developing state that faces challenges in common with other South Pacific countries, such as exposure to natural hazards like tsunamis or volcanic eruptions, imbalanced economic growth, and food security concerns. Around two-thirds of Samoa's population is aged under 30, with a youth unemployment rate of about 18%.[188] Young women tend to face more obstacles securing employment than their male counterparts.[189] In direct response to the government's objective of reinvigorating agriculture and supporting the development of organic food production, the Farm to Table program helped to reduce youth unemployment by focusing on links between agriculture and tourism.

Farm-based employment and vocational training in organic farming methods, as well as institutional capacity building, were key components of the program. The project has been supported by a coalition of partners, including the United Nations, government agencies, as well as youth, women, and trade organizations. Private companies, such as hotels, restaurants, food processors, and exporters, supported implementation by indicating a strong readiness to buy local organic produce directly from the farmers.[190] A Farm to Table mobile app was developed and launched by the Samoan Women in Business Development Incorporated (WIBDI) organization, serving to connect organic farmers with markets.[191] [192] It also allowed tourists and locals to find restaurants offering organic food produced by program participants.

In the first two years, a total of 574 youth, 1,027 farmers, 137 children, 30 businesses, and 61 NGOs benefited directly from the project; WIBDI trained the youth in organic agriculture methods and certified the farmers.[193] Successful young graduates have sold their produce directly to night markets, immediately benefiting from their training. Gender mainstreaming in all program activities was an important component with equal representation among beneficiaries and in decision-making bodies, such as organic certification committees and production clusters.[194]

2.2.5 INDIGENOUS AND DISPLACED PEOPLES

Indigenous and displaced peoples have often been subjected to or have fled from discrimination in their places of ancestral origin. For them, migration is frequently forced and compulsory, and their fundamental rights and freedoms are often severely curtailed. Their lives and livelihoods as displaced communities are commonly characterized by further discrimination, especially when entrenched patterns of exclusion are replicated elsewhere.[198]

Land Back Movement

Around the world, indigenous peoples lost their land to settlers during colonization and to commercial interest afterwards. With the UN Declaration on the Rights of Indigenous Peoples (2007) as a guiding framework,[199] they are now engaging more rigorously with governments, businesses, and local communities to reclaim their rights to ancestral lands. The Land Back movement is based on the rightful return of culture and identity, indigenous law and governance, and environmental values. This can involve stewardship, sovereignty, or rights like a nation state, but above all it must convey the power to access and control natural resources and full enjoyment of their benefits within a territory.[200] The Land Back movement is part of the multi-dimensional, racial, and economic justice movement that is sweeping the globe.[201] [202]

A range of strategies have all seen success. Indigenous peoples are buying land back, demanding court orders, creating trusts and legal agreements, or receiving land transfers, taxes, and rent from governments, NGOs, or other users.[203] [204] When reinstated, indigenous governance tends to promote co-management arrangements involving other nations or tribes, local communities, and relevant government departments. As a result, the Land Back movement offers many opportunities for the restoration of traditional, regenerative land and water management practices, which could be applied throughout large parks, public lands, and protected areas. The movement is aligned with global campaigns to protect biodiversity, expand indigenous management of protected areas, and restore natural capital to mitigate and adapt to climate change.[205]

Australia: Aboriginal Return

The Daintree National Park in eastern Cape York, Australia, is a UNESCO World Heritage site, part of Australia's largest continuous area of tropical rainforest and home to many generations of Aboriginal people, one of the world's oldest living cultures. In 2021, over 1,600 square kilometers of rainforest, including three other national parks, were returned to Eastern Kuku Yalanji ownership to be managed jointly with the Queensland Parks and Wildlife Service.[206] The handback recognizes the unique knowledge of the Kuku Yalanji and their inalienable right to own and manage their land, protect their culture, and share it with visitors. Since 1995, a wider Cape York land tenure resolution process has returned some 40,000 square kilometers to Aboriginal ownership, half jointly managed and half freehold land.[207]

USA: Forest Management

In the state of Montana, the Confederated Salish and Kootenai Tribes (CSKT) of the Flathead Reservation resumed control over forest management on their reservation in 1988. This led to increased species diversity and a healthier tree age distribution, making reservation forests less prone to wildfires while providing better wildlife habitat and higher water quality compared to land managed by the US Forest Service. The CSKT and many other indigenous peoples have demonstrated their capacity to create jobs and reap economic benefits from sustainable forest management.[208] In 2020, federal legislation was signed to transfer the management of a key bison herd rangeland back to the CSKT.[209]

Canada: Mushroom Permits

The Tŝilhqot'in Nation is comprised of six communities in British Columbia, Canada. In May 2018, following a devastating forest fire, the Tŝilhqot'in introduced regulations that required all outsiders to purchase a permit to harvest mushrooms on their land. The regulations include a Leave No Trace policy, which requires all guests to preserve the condition of land and waters. After just one harvesting season, the Tŝilhqot'in ensured widespread compliance with the regulations from non-indigenous harvesters and measurable economic benefits from the initiative. They have also created alliances with other nations (e.g., Dãkelh) to protect land resources and a declining moose population. As a result, a ban on non-indigenous hunters has been enacted, and activities to promote cultural revitalization and sustainable economies have borne fruit.[210]

Refugees, Rights, and Restoration

By the end of 2020, it is estimated that over 82 million people worldwide were forcibly displaced, including refugees and international migrants.[211] In 2020 alone, conflict and natural disasters triggered over 40 million new internal displacements, with more than half under the age of 18.[212] A host of new and volatile land-related problems have arisen due to these large population dislocations. Competing claims to land by refugees, internally displaced people, and host communities are further complicated when tenure and rights have been largely undocumented. [213] The COVID-19 pandemic has further aggravated efforts to address these problems

as many local authorities have stopped receiving donor aid for land administration, resettlement, return migration, or job creation schemes.[214]

Uganda: Refugee Rights

Uganda is home to 1.5 million refugees from conflict-ravaged neighboring countries such as the Democratic Republic of the Congo and South Sudan.[215] Since 1999, the government has pursued a self-reliance model based on the local social and economic integration of refugees.[216] Refugees receive a plot of land for farming purposes, enjoy free movement, and a right to work and establish businesses. They can own property, attend school, and access health services.[217] [218] This welcoming environment, supported by the government's Jobs and Livelihoods Integrated Response Plan for Refugees and Host Communities in Uganda 2020-2025, is providing tangible benefits and renewed dignity for refugees and their host communities.[219]

Uganda's Bidibidi refugee camp, with 270,000 mostly South Sudanese residents, is the world's largest.[220] Local residents and refugees live, farm, and work together, fostering the growth of small businesses and attracting better infrastructure and services. The Ugandan government's goal is to build a city that can endure when refugees eventually return home.[221] [222] There is little to distinguish Bidibidi from the surrounding countryside – it has the same green patchwork landscape of banana palms, mango trees and small farm plots with thatch-roofed brick and mud homes. A small-scale local economy has developed organically with markets, schools, and health clinics.[223]

Another example of integration is supported by the work of the Ugandan Youth Initiative for Community Empowerment.[224] The Initiative was created to respond to the struggle of refugee communities to become self-reliant, mostly due to the small plot sizes and low quality of the land given to them.[225] It engages refugees in sustainable agriculture (e.g., permaculture, agroforestry) and irrigation practices in the Bukompe refugee settlement. To date, over 100 women farmers have been trained in permaculture techniques, with 20 kitchen gardens established.[226] [227]

North Africa and the Sahel: From Migration to Restoration

Climate and environmental factors as well as limited employment opportunities drive migration along the central Mediterranean route from countries in north Africa and the Sahel.[228] Many households in these countries have, in recent years, experienced drought, land degradation, water scarcity, or extreme weather events which led to a loss of crops, livestock, and income. The Initiative on Sustainability, Stability and Security (3S), launched in 2016, is a regional government-led effort with 14 participating countries.[229] Its main objectives are to mitigate the impacts of climate change by increasing the area of arable land and forests, and reduce migration pressures by creating new rural jobs through investments in agriculture, agri-business, and forestry.

The 3S Initiative is supported by the International Organization on Migration (IOM) and the UNCCD, which are jointly implementing a stabilization project in Agadez, Niger.[230] It assists with migrant reintegration and countering radicalization by creating meaningful jobs to restore degraded lands. Over 200 hectares of land have been set aside for the project, with 30 hectares already restored and allocated to selected beneficiaries with roots in Niger, such as unemployed youth, former smugglers, and returning migrants. Each beneficiary has received cash grants and one hectare of land for sustainable income-generating activities. In addition, 500 West African migrants have been trained in sustainable land management practices in anticipation of their return to their countries of origin.

Bangladesh: Refugees Restoring Forests

Since August 2017, Bangladesh has provided shelter and refuge to almost one million displaced Rohingya people from Myanmar in several camps in and around the forests surrounding the city of Cox's Bazar.[231] To accommodate such a mass influx of refugees, forest land was cleared to build spontaneous settlements,[232] threatening regional biodiversity, wildlife habitat, and ecosystem services, and making existing settlements more vulnerable to mudslides, flooding, or cyclones.[233] In addition to emergency humanitarian aid, a forest and landscape restoration program was initiated to increase forest and vegetative cover by engaging refugee households in planting native trees, shrubs, and grasses in and around the camps. As of 2020 – with the support of local and international organizations and through a cash-for-work initiative – refugees have restored nearly 258 hectares of degraded land inside the camps, and a further 2,000 hectares of forest surrounding the camps, including implementing measures to protect elephants.[234]

2.2.6 SUSTAINABLE VALUE CHAINS

Many businesses and corporations are now seeking to embed fair labor practices and environmental responsibility throughout their supply networks. Many consumers indicate that social and environmental concerns are key to the purchasing choices they make. Their purchasing power provides a clear incentive for businesses to pursue not only profit, but also goals aligned with environmental, social, and governance (ESG) criteria. Sustainable supply chain commitments require substantiation and documentation through a hands-on approach to collecting data about suppliers' capacity, monitoring sustainability performance metrics, and engaging them to deliver continuous improvements. Any supply chain – and the sustainability credentials of businesses reliant on such chains – is only as strong as its weakest link.[235]

Indonesia: Big Tree Farms

Founded in 2006, Bali's Big Tree Farms produces and exports organic coconut-, cacao-, and cashew-based foods. The company's mission is to inspire positive supply chain change by creating innovative and healthy food products that also benefit local economies, ecosystems, and farmers. Big Tree Farms works directly with over 14,000 small farmers to create transparent, socially equitable supply relationships and products. Inspired by a 'we live where we grow' mantra, the company seeks to help mitigate climate change and promote regenerative agriculture to conserve millions of trees which support rich and stable ecosystems.[236]

Big Tree Farms' inclusive business model is based on applying Fair Trade principles with farmers and throughout the supply chain. This includes assistance to farmers with organic and Good Agricultural Practice (GAP) certification, agreements with traders on prices and collection points, and advancing credit for processing equipment. The strategy gives farmers a lucrative market for their produce and has also turned Big Tree Farms into Indonesia's largest organic food company, with an organic supply chain extending throughout Southeast Asia.[237] In addition to paying Fair Trade per kilo premiums that go directly to farmers, Big Tree Farms also sets aside a ring-fenced levy for community development priorities to deliver a truly sustainable and equitable supply chain model.[238]

Côte d'Ivoire/Ghana: Cocoa and Forests Initiative

Deforestation is a major issue in Côte d'Ivoire and Ghana, which together produce nearly two-thirds of the world's cocoa. Respectively, they lost 26%[239] and 10%[240] of their primary forest between 2002 and 2020 – with cocoa farming as a significant cause. To end deforestation and restore forest areas, both governments, together with 35 leading cocoa and chocolate companies, including Nestlé, joined forces in 2017 as the Cocoa and Forests Initiative. This public-private partnership is structured around three critical actions: forest protection and restoration; sustainable production and farmers' livelihoods; and community engagement and social inclusion.[241] To ensure a sustainable supply chain, Nestlé mapped over 75% of the 120,000 cocoa farms it buys from, accurately marking boundaries using GPS, to ensure zero encroachment on protected forests. In addition, more than 560,000 native and fruit tree seedlings were distributed and planted to increase the proportion of climate-resilient, shade-grown cocoa and supplement farmers' incomes. Over 85,000 farmers participated in training programs on good agricultural practices and forest protection, and 9,400 people received financial support from the creation of village savings and loan associations.[242]

Mongolia: Sustainable Cashmere

In Mongolia, cashmere is often the primary source of income for many nomadic herder communities, which comprise around one-third of the country's population. Cashmere exports are significant, at around 10,000 tonnes annually, making up almost 5% of the country's GDP. In the last 20 years, herders have increased their livestock numbers significantly to bolster incomes, yet to the detriment of the steppe's natural environment. By 2020, total herd size in Mongolia was estimated at over 80 million, double the carrying capacity of the land,[243] with over 75% of the country's rangeland considered degraded.[244]

Mongolia is well positioned to offer sustainable, rangeland-based goods and services to its citizens and global consumers who place a premium on sustainable products. The international NGO Agronomes et Vétérinaires Sans Frontières (AVSF) is working with pastoral communities and district authorities in three provinces in the arid and mountain steppe regions to promote sustainable rangeland management and inclusive rural economic development.[245] While all land in Mongolia is owned by the state, pasture lands

© Batuhan_dogan-unsplash

are managed by herders and district authorities. Rangeland User Agreements, recognized by district authorities, provide secure tenure and access rights and form a key part of local land management plans. Individual cooperatives operate revolving funds for sustainable natural resource management (e.g., protection of water sources), animal feed (e.g., fodder sold at cost to members), and risk management (e.g., mitigating climate disasters) as well as investment and social funds. The Sustainable Cashmere Union pools cooperatives' production, finds buyers, negotiates sales, allocates equitable purchase orders between members, and builds trust with upstream clothing brands. When needed, coordination and conflict resolution is carried out by a Pasture Management Coordination Body, which includes officials, elected representatives, and civil society.

The Sustainable Cashmere Program was launched in 2013 to develop sustainable cashmere value chains and demonstrate how land restoration can also improve the livelihoods of pastoralists. It emphasizes product quality and the equitable distribution of profits throughout the value chain. It sources sustainable and certified raw material, supports textile processing by small and medium enterprises, and promotes Mongolian sustainable fibers in national and international markets. The program currently includes 5,000 herder households, over 200 pasture user groups, and 15 herder cooperatives as well as many processing enterprises. It costs USD 433 for each herder household to participate in the scheme, and about USD 550 to restore 1,000 hectares of rangeland. Even after a 30% decrease in herd size, herders' incomes went up by an average of 50%.

Argentina: Union of Land Workers

The Union of Land Workers is committed to creating a new food paradigm in Argentina,[246] countering a business model controlled by large landowners that has reduced the food and nutritional diversity available to the population.[247 248] The union, created in 2011, organizes small-scale farmers and rural land workers to grow fruits and vegetables organically. It now includes a network of 10,000 households directly selling their produce at fair market prices in major cities around the country, without intermediaries.[249 250] In partnership with the National Institute of Agriculture Technology, the union shares expertise on agroecological production techniques, provides inputs (e.g., organic fertilizers, non-GMO seeds), and assists families with certification and land legal issues.[251]

Timor-Leste: With One Seed

As a young small island developing state, Timor-Leste has been economically dependent on oil and gas exports since its independence in 2002. However, most rural communities still rely on subsistence farming. The With One Seed community forestry program aims to create opportunities that emphasize protecting and restoring the environment and boosting subsistence incomes, while supporting renewable energy, fossil fuel divestment, and urgent climate action. The goal is to replace charity and aid with sustainable livelihoods that bring respect, self-esteem, self-determination, and self-reliance to communities.

With One Seed began in Baguia village in 2009. It has since established village-based plant nurseries to grow seedlings, provided education and training, and paid smallholders annual incentives to plant and maintain trees. Nearly 1,000 subsistence farmers are now involved, and 200,000 trees have been planted, earning over USD 400,000 from the sale of carbon credits. Reforestation has improved soil and water quality, boosted crop yields and nutrition, delivered better community health and wellbeing, and promoted a model for regenerative development across Timor-Leste.

With One Seed has developed and rolled out a technology platform (TreeO2) that uses tags so that each planted tree has a unique and trackable ID. This allows the program to maintain a data dashboard, including the number of trees managed by each farmer, planting dates, species, GPS location, tree size (circumference), the carbon stored, and farmer payment information. This rich source of information plays a significant role in managing the new forests and generating performance audits for certification and the sale of carbon credits. The European Union has recently contributed USD 3.4 million to enable the With One Seed program to extend its activities across the country.[252]

Spain: Regenerative Supply Chains

In the semi-arid steppe environment of the Altiplano Estepario in southern Spain, water is scarce and climate conditions are extreme. In 2014, Commonland mobilized local farmers, entrepreneurs, and other stakeholders to embark on an ambitious and large-scale dryland restoration effort to halt desertification and soil erosion and bring back prosperity using the 4 Returns Framework.[253] The producer association (AlVelAl) supports farmers to transition to regenerative farming practices across the Altiplano. Techniques employed include constructing swales, restoring terraces, planting green cover crops, and creating wind breaks to conserve soil and water and enhance biodiversity. By 2020, 140,000 trees had been planted, 200,000 seeds sown by drone, and two thriving cooperatives established that process produce from AlVelAl farmers. The aim is to strengthen supply chain links to AlVelAl Foods, which sells regeneratively grown products directly to consumers, including almonds, pistachios, walnuts, wine, honey, aromatic herbs, and olive oil.[254]

Brazil: Palm Oil Sourcing without Deforestation

The Brazil-based cosmetics brand Natura specializes in natural product formulations and is strongly invested in agroforestry to ensure palm oil it uses is harvested sustainably. In the State of Pará, an agroforestry system was designed to deliver shade for secondary species, such as cacao and black pepper. According to their performance under local conditions, other high-value species were selected to increase soil fertility or to provide mulch. The system – based on manual land preparation, organic fertilizers, and the use of plant residues from pruning and weeding – was designed to accommodate local farmers' desires to grow their own subsistence staples, such as cassava, beans, cacao, and açai, alongside cash crops. After five years, oil palm yields are higher on average than those produced in monocultures. In one plot, carbon stocks were higher than in secondary forests or conventional agroforestry systems.[255]

© garrete-reis-unsplash

Green Jobs and Entrepreneurship

The global scale industrial, agri-food systems complex has largely failed producers, consumers, and the planet. Widespread food crimes, including the application of harmful pesticides, animal cruelty in factory farms, and many other illegal practices[256 257 258 259 260 261 262] renders it doubtful whether these industries and their associated supporters can assume the appropriate authority, capacity, and mindset[263 264] to play a meaningful role in tackling the world's pressing environmental and social challenges.

The time is ripe to empower local entrepreneurs to help create local solutions to these difficult challenges in an ethical and equitable manner.[265] Hundreds of inspiring, innovative, and often young entrepreneurs are already making a difference across the world – boosting agricultural yields, revitalizing degraded land and soil, and creating meaningful jobs for the future. They employ a wide range of locally led, market-driven green business models that protect and restore farmland and forests, transform agriculture and provide sustainable, long-term economic opportunities for local communities struggling to build back from the COVID-19 pandemic. There are many inspiring examples across the world's diverse landscapes and ecosystems of agile and innovative small businesses creating solutions to improve human health and the quality of life on land.

Africa

The Kenyan precision agriculture company **Lentera Africa**[266] works with farmers to fight pests and disease, boosting yields by nearly 50% on some farms,[267] while eliminating the need for chemical fertilizers. Lentera harnesses new technologies – from drones to weather monitoring apps – to precisely identify the inputs and techniques best suited to each plot of land. **Agro-Eco Services**,[268] located in Benin, uses the larvae of the black soldier fly to convert food waste into compost and chicken feed. The company provided over 1,500 farmers with a total of 150 tonnes of organic fertilizer in 2020 and expects to quadruple this in 2021.[269] **CADEL Business**[270] turns Burkina Faso's cotton waste into organic compost by enriching it with natural phosphate. The business has restored 500 hectares of degraded land and improved crop yields for over 1,500 farmers.[271] **Recycl'Africa**,[272] in Rwanda, transforms polluting organic waste from the city landfill in Musanze into organic fertilizer for farmers, reducing the need for chemical fertilizers and increasing soil health and crop yields.

Nature's Nectar,[273] in Zambia, trains and equips smallholders in beekeeping, honey, and wax production to attain fair prices, be women-inclusive, and protect local ecosystems. Since its foundation in 2018, the company has helped 2,000 smallholders and restored 10,000 hectares of land.[274] **Agriworks Uganda**,[275] founded in 2016, provides affordable irrigation to smallholders by upcycling motorcycle engines into mobile water pumps. Agriworks offers an on-demand service that helps over 500 smallholders grow market-quality vegetables during the dry season, providing a significant income supplement as well as nutritious food for local communities.[276] The Tanzanian company **N'gwala Inventions** helps farmers produce their own bio-pesticides and fertilizers by placing automated processors on farms and in communities. By eliminating transport costs and ensuring a constant supply of local farm inputs, the company helps boost farmer incomes.[278]

Ghana: Creating a Network of Women Farmers

In Ghana, **Tilaa**[279] is a company working with farmers to produce cashews, animal feed, honey, and other high-value bee products. By integrating beehives and cashew trees into croplands, it assists a network of over 500 women farmers in adopting climate-friendly land use practices and defending their land against desertification. Since 2015, Tilaa has distributed over 120,000 cashew saplings to restore 300 hectares of degraded land. The women in the company's network report that their annual disposable incomes have quadrupled to USD 2,000. In addition, participating farmers enjoy membership in Ghana's National Health Insurance Scheme.[280]

Middle East and Asia

In Egypt, the start-up **Plug 'n' Grow**[281] develops aquaponics and hydroponic-based agricultural solutions to maximize the use of renewable energy to address food security and water scarcity issues, which arise from desertification, urbanization, and climate change. In the United Arab Emirates, **Desert Control**[282] deploys a non-intrusive soil recovery technology based on Liquid Natural Clay, a nano clay that can convert unproductive desert land into fertile soil. **St. Jude's Herbals**,[283] in India, has developed a unique nature-based solution called 'plantopathy' that can limit the impact of plant diseases on yields without pesticides or chemicals, while improving soil health and reducing costs to farmers. **Rhodotion**[284] has created a mixed farming system in northeast India, integrating coffee, avocado, and orange trees, and herbs alongside tea bushes. This system has stabilized land and helped deliver a threefold increase in traditional income for over 300 farmers in north Bengal.[285]

SenzAgro[286] is a precision agricultural firm that markets soil sensing and smart irrigation systems, active on seven farms covering 10,000 hectares across Sri Lanka, claiming to increase yields by 20%, decrease water consumption by 40%, and lower the use of pesticides and fertilizers by 40%.[287] **Village Link**,[288] in Myanmar, is a technology company that helps enable agricultural and rural communities to use mobile applications. By harnessing advanced satellite capabilities, international expertise in agriculture and meteorology, and extensive business partner networks, the company delivers precision farming advice and market access to smallholders across the country.[289]

Latin America and the Caribbean

Costa Rica's **HEVEA**[290] is growing 150,000 natural rubber trees on over 300 hectares of degraded pasture, creating a long-term source of income for local farmers.[291] **Prontal**,[292] in Mexico, harnesses the power of 25,000 native, dye-producing palo de tinto trees[293] to transform abandoned pastureland into sustainable commercial plantations. Since 2017, Chile's **Relicto**[294] has conserved and restored some 200 hectares of land each year, targeting areas with important native plant and animal species.[295] It works directly with landowners to grow native trees as well as design and manage biodiverse landscapes. In Nicaragua, **Nicaforest**[296] works with local communities to revitalize damaged pastures and grow FSC certified cacao, teak, and native trees on over 550 hectares.[297] The **Adapta Group**,[298] in Brazil, is growing marketable native plants, like cactus and agave, on formerly degraded pasture in a unique agroforestry system. **Revofarm**[299] is a Jamaican startup developing SMS and web-based applications to deliver weather and agronomic data to farmers, empowering them to make smart, field-level decisions to boost yields. Revofarm's ambition is to make agriculture more attractive and sustainable by reducing input costs and maximizing incomes for farmers.[300]

Developed Countries

In the UK, **Dendra Systems**[301] uses custom-built drones, alongside ecological and artificial intelligence, to assist multi-national companies to clean up and restore degraded land. In 2020, Dendra launched a third-generation aerial seeding technology and analysis platform that allows clients to rehabilitate degraded land 11 times faster than traditional methods of remediation, replanting up to 60 hectares daily.[302] The Canadian agri-tech company, **Terramera**,[303] offers plant-based pest control products and a platform for regenerative agriculture called 'Actigate'.[304] This platform reduces synthetic chemical loads and makes organic alternatives more effective, rendering agriculture healthier, more sustainable and more productive while committing to reduce the global burden of chemical pesticides by 80% by 2030.[305] A Swiss-British company, **Mootral**,[306] develops feed supplements for cattle that reduce methane emissions from cows, goats, and sheep up to 38%. **Tierraponica**,[307] based in Japan, has a unique hydroponic technology that uses various types of organic waste from food factories to cultivate premium quality and highly nutritious vegetables while promoting a circular economy. It can cultivate in any location from rooftops to indoors using conventional hydroponic equipment.[308]


© Jason Houston_USAID

2.3.1 CONSERVATION AND PROTECTED AREAS

Protected Areas (PAs) are critically important, yet they are threatened globally. Their existence, management, and long-term stability help safeguard critical biodiversity and ecosystem functions from local to global scales.[309] PAs are an effective climate solution and currently the only significant counterbalance to deforestation and land degradation, which contribute significantly to carbon emissions. PAs are often the only remaining habitat for vulnerable or specialized species, yet more effective management, enforcement, and ecosystem restoration will be needed to maintain or recover threatened populations.[310]

Raising Ambition

In 2010, the Convention on Biological Diversity adopted the Aichi Biodiversity Targets as part of its ten-year Strategic Plan for Biodiversity. Aichi Target 11 set out the main international action framework for PAs:[311] "By 2020, at least 17% of terrestrial and inland water, and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes".[312]

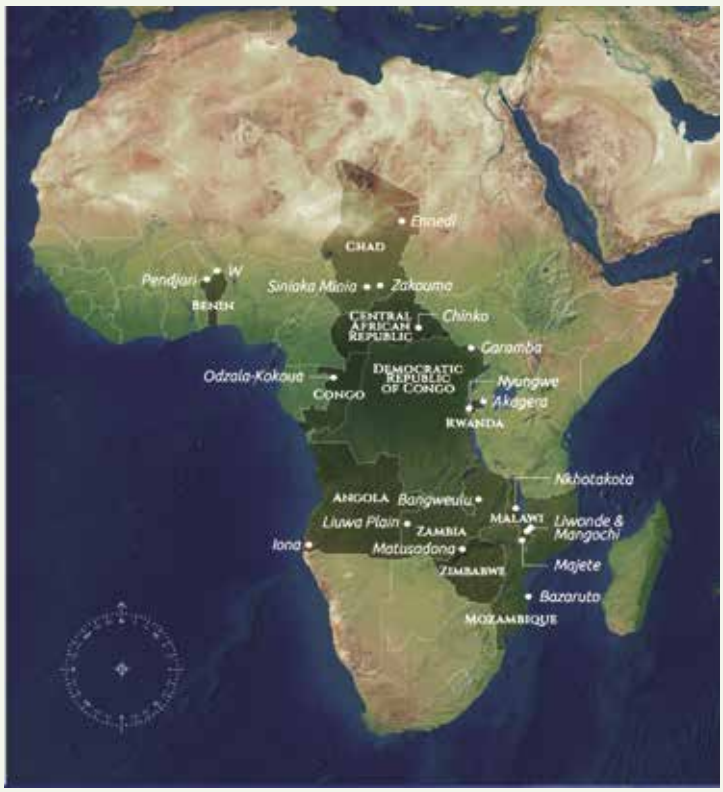
From 2000-2020, PAs have expanded their coverage from around 10% to over 15% of terrestrial ecosystems,[313 314] coming very close to meeting the ambition of Aichi Target 11. The post-2020 global biodiversity framework – to be agreed in 2022 – is expected to include a specific target to further raise the level of ambition for PA coverage by 2030.[315] The goal of protecting 50% of the terrestrial biosphere is being advocated to fully address the species extinction crisis and conserve a global ecological heritage for future generations.[316] Existing mechanisms, such as Other Effective Area-Based Conservation Measures (OECMs) and Indigenous Community Conservation Areas (ICCAs), will continue to play a key role in achieving future PA and other area-based conservation targets, both in terms of extent as well as their connectivity and integration within wider landscapes.[317]

Effective management and adequate resourcing are vital to realize desired ecological outcomes in PAs,[318] and for that there are a variety of governance models.[319] National policies and programs can also have a large impact.[320] Indigenous peoples and local communities often live and work in and around PAs.[321] Collaborative management involving these communities tends to be associated with the delivery of greater local benefits than state management alone.[322] Inclusive governance models are frequently used to manage PAs, such as private-public partnerships,[323] private-NGO, or community-based approaches.[324] In addition to improved livelihoods, capacity development and security of tenure often result in improved management outcomes in PAs.

African Parks: Public-Private Partnership Model

African Parks (AP) manages 19 parks in 11 countries in sub-Saharan Africa, covering 14.7 million hectares of land and encompassing 10 of the 13 biomes on the continent. AP was founded in 2000 to address the deterioration of ecological integrity in PAs due to a lack of resources, capacity, and political stability. The AP public-private partnership model emphasizes biodiversity conservation and monitoring, park management and infrastructure development, tourism, law enforcement and anti-poaching patrols, and community development. Each park has a local governance board, an established legal entity composed of civil society, government, and AP representatives. During the COVID-19 pandemic, all AP parks continued to serve as centers of security in which wildlife populations increased, schools, and clinics functioned, and social enterprises received investments.[325]

FIGURE 2.4 The African Parks portfolio



In 2014, the government of the **Central African Republic** and AP first established their partnership. In 2020, the Chinko wildlife refuge was expanded to 55,000 square kilometers as part of a 25-year agreement, creating one of Africa's largest contiguous protected management wilderness areas. Chinko's goal is to conserve the country's natural assets while providing benefits for local people. Before the establishment of the refuge, poaching was widespread, and the landscape was overrun by hundreds of thousands of cattle and armed herders. Now a core area of 13,500 square kilometers is free of poaching and 23,000 square kilometers is clear of cattle. The Chinko is already the largest employer in the region and has seen dramatic increases in wildlife populations.

Rwanda's Nyungwe National Park forms the core of one of the 'archipelagos' of Afromontane rainforests in eastern Africa. Nyungwe is of paramount importance, both locally and globally, providing 70% of Rwanda's water supply and containing 25% of Africa's primate species. In recent times, it has suffered from wildlife poaching, illegal mining, and encroachment from agriculture. In 2020, the government and AP signed a public-private partnership to protect its fauna and flora and increase conservation-based tourism to support local communities.

The Pendjari National Park in **Benin** forms the backbone of the 32,250-square-kilometer transnational W-Arly-Pendjari Complex, spanning Benin, Burkina Faso, and Niger. It is the largest intact natural ecosystem in West Africa and has been threatened for years by a lack of management and resources, growing human pressures, and increasing political instability. In 2017, the Benin government invited AP to manage and revitalize the park through tourism and enterprises that support local communities. In just three years, Pendjari now has the largest, professionally trained group of rangers in its history, with important ecological research and monitoring being conducted. In 2020, the Benin government invited AP to manage W-Benin National Park, an anchor of the W-Arly-Pendjari Complex and a UNESCO World Heritage Site.[326]

Kenya/Canada: International Cooperation for Climate Change Adaptation

In Kenya, interventions to enhance adaptive capacity in six national parks and their adjacent local communities to climate change impacts were undertaken in a partnership between the Kenya Wildlife Service (KWS) and Parks Canada. It helped to raise funds and create a common vision to design an implementation framework, identify capacity needs, and define roles and responsibilities. Activities to enhance resilience of the PAs focused on the ecological restoration of degraded habitats, management of invasive species, enhancement of water supplies for people and wildlife during the dry seasons, and capacity building for KWS staff and local communities.[327] [328]

Colombia: Scaling Up Zero-Deforestation Initiatives

In Colombia, ending deforestation is central to peace-building strategies and reducing emissions under the Paris Agreement. The government plays a critical role in establishing conditions for the uptake and coordination of zero-deforestation initiatives. It has aligned domestic public policies for reducing emissions with numerous REDD+ projects and supply chain initiatives designed to eliminate deforestation. Through public-private partnerships, the government leverages non-state expertise and financing for projects, while retaining sovereignty and keeping them aligned with national priorities. Centralized monitoring is used to control and coordinate these projects. Businesses can pursue zero-deforestation in their supply chains in return for risk-sharing with the government. These multi-stakeholder partnerships support 10 zero-deforestation pledges and advance implementation directly through nested commitments, or indirectly by improving territorial planning, institutional capacity, and on-the-ground technical assistance.[329]

Jordan: Developing Low-Impact Ecotourism

The Ajloun Reserve managed by Royal Society for the Conservation of Nature (RSCN) covers 12 square kilometers in northern Jordan, consisting primarily of fragmented forest patches. The reserve has suffered due to deforestation, grazing, hunting, and dumping. Recently, the RSCN created several ecotourism and socio-economic projects that have generated employment and improved infrastructure (e.g., transport, water, energy) while at the same time enhancing conservation programs. As a result, the reserve has become an economic driver in the region, with most of its budget spent as salaries, goods and services directed to, or procured from, local communities.[330]

Democratic Republic of the Congo, Rwanda, and Uganda: Regional Collaboration

Due to an increase in threats to PAs, such as poaching and encroachment, a joint initiative was undertaken by the three countries to better protect eight adjoining PAs within the Greater Virunga area, demonstrating that conservation across borders is possible, even amid armed conflicts and political unrest. There are agreements at a ministerial level to pool resources and work together to protect biodiversity and keystone species, such as gorillas. These efforts include activities to bolster the economic development of local communities, such as beekeeping, eco-tourism, and the construction of water tanks. A joint surveillance system staffed by rangers from the three countries is being implemented across national borders. Intelligence on illegal activities is shared among all park managers, creating a more informed and unified enforcement approach.[331]

Belize, Guatemala, and Mexico: Transboundary Conservation in the Selva Maya

The Selva Maya is the largest contiguous tropical forest area in Mesoamerica, covering over 100,000 square kilometers in the border area between Belize, Guatemala, and Mexico. With 23 different ecosystems represented in 40,000 square kilometers of PAs, it is a hotspot of biodiversity but also home to some 600,000 people. Starting in 2015, there have been considerable efforts to promote effective cross-border cooperation and improve environmental governance. Through exchanges of park rangers from PAs on both sides of their borders, PA managers have been able to identify common challenges and develop joint planning agendas. The improved lines of communication between local authorities have resulted in more effective management of the PAs as well as increased environmental awareness in border communities. Training exercises and knowledge exchanges have strengthened the capacities of park rangers to significantly reduce the impacts of illegal hunting, logging, and wildfires. A joint monitoring program for key species, like jaguars and tapirs, has reduced poaching and provided a better understanding of their population dynamics. A working group at the federal level in all three countries serves as a political coordination mechanism for transboundary PA management.[332] [333]

Improving Connectivity

Ecological connectivity is the unimpeded movement of species and the flow of natural processes that sustain life on Earth.[334] Connectivity within and between PAs and other conservation areas ensures the long-term persistence of biodiversity and ecosystem services.[335] Globally, while 42% of terrestrial land is intact, only 10% of the area under protection is structurally connected with functional pathways throughout ecosystems and landscapes.[336] Restoring connectivity both within and between PAs is seen as a priority worldwide to increase their effectiveness in combatting biodiversity loss and climate change.[337]

Thailand: Forest Complexes

Thailand has recently expanded its protected areas system, which currently numbers 128 terrestrial parks, 26 marine parks, 60 wildlife sanctuaries, and 63 non-hunting areas – all of which are managed by national authorities. To promote connectivity, the concept of ecological networks has been adopted and includes the planning and design of forest complexes. These involve national parks and wildlife sanctuaries being jointly managed to form a larger area and together support viable populations of a wide range of plants and animals. The Western Forest Complex is the largest, covering nearly 15,000 square kilometers. The complexes are also being managed to deliver regional development through enhanced livelihoods and ecosystem services. Tiger populations are rebounding, deer have been reintroduced, and many other species have returned their historical ranges.[338]

USA/Canada: Yellowstone to Yukon Conservation Initiative

Fragmentation along the 3,200-kilometer-long Yellowstone to Yukon (Y2Y) mountain region in western North America is negatively impacting natural processes, wilderness areas, and wildlife habitat. While the USA and Canadian governments have classified approximately 80% of Y2Y lands as public and 20% as private or tribal reservation lands, there remains an inefficient and incoherent myriad of jurisdictional authorities. Since 1993, the joint Y2Y Conservation Initiative has brought together over 400 different entities to reconnect and protect the region. Efforts to enhance connectivity have focused on large, well-positioned PAs, privately conserved lands, or other lands under long-term management. The area protected has increased by over 50% across the Y2Y region as ecological corridors and other conservation areas have been designated, restored, or sustainably managed. Human-wildlife conflicts have decreased while some species, such as grizzly bears and wolves, have increased in number and range.[339]

Kenya/Tanzania: Wildlife in Transboundary Landscapes

The transboundary Kilimanjaro Landscape stretches from the Amboseli, Chyulu and Tsavo West National Parks in Kenya to Mount Kilimanjaro National Park in Tanzania. The Amboseli forms the core of the larger connected landscape, but is too small to support viable populations of wildlife. In 2008, the African Wildlife Foundation launched a conservation lease program in the surrounding areas to protect strategic ecological corridors, prevent further habitat conversion, and provide economic incentives directly to ranchers and landowners to keep their land open for wildlife passage. Payments for ecosystem services are key to the success of the program, which engages with five community conservancies, involving more than 350 landowners in the protection of approximately 8,000 hectares of ecological corridors. While the lease program benefits thousands of people and creates opportunities for wildlife scouts, it relies heavily on donors for its operations.[340]

Costa Rica: Biological Corridors and Land Use Planning

Costa Rica is a relatively small country of 51,000 square kilometers, yet has nearly 6% of global biodiversity, and hosts a unique blend of species at the juncture of the North and South American continents. The protection and restoration of biodiversity is a top priority in the country's land use and development planning. PAs and biological corridors are the primary conservation strategy to maintaining species habitat and ensuring ecosystem integrity. Recent efforts focusing on restoration activities and numerous connectivity programs are managed by the national government and by participatory platforms called Local Committees.[341] Municipal land management plans provide the blueprint for managing human development activities while maintaining healthy and sustainable landscapes. For example, the Canton of Garabito contains the Paso de las Lapas Ecological Corridor, which connects PAs in the mountains (e.g., La Cangraja National Park, Cerros de Turrubares, Carara National Park) with those on the coast.[342]

2.3.2 ECOLOGICAL RESTORATION AND REWILDING

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.[343] Similarly, rewilding, a term which has recently gained currency in the media, seeks to restore the ecological functions of native species and their interactions (e.g., food webs), enhance connectivity within and among habitats, and promote natural ecosystem dynamics and vegetation succession.[344 345] Ecological restoration and rewilding aim to reinstate the pre-disturbance condition or trajectory of native ecosystems for the benefit of people and the planet. Both approaches also consider economic trade-offs and competing land uses like agriculture, urbanization, and infrastructure.

South America: Rewilding and Conservation Philanthropy

Argentina and Chile's huge territories boast enormous biodiversity. Their ecosystems include rainforests, high altitude forests, sub-tropical savannas and grasslands, deserts, temperate prairies and steppes, coastal wetlands, high mountains, and ice caps. However, many ecosystems are severely degraded with native wildlife devastated by hunting, cattle ranching, or rice farming. From the first Chilean land purchase in 1991 to an awe-inspiring sweep of protected landscapes and ecosystems today, the efforts of outdoor pioneer Doug Tompkins and his wife Kristine McDivitt have shaped the rewilding movement well beyond their adopted home in South America. By establishing and protecting over 60,000 square kilometers of protected parklands in Chile and Argentina, these founders and former CEOs of North Face and Patagonia created a whole new strand of conservation philanthropy, inspiring others to follow in their footsteps. Despite Tompkins' death in 2015, his work continues today with Tompkins Conservation and Rewilding Argentina, organizations that manage extensive conservation programs in South America in partnership with national and regional governments.[346]

Argentina: Rewilding the Iberá Wetlands

The Iberá wetlands comprise the largest freshwater aquatic ecosystem in South America and are the focus of an ambitious rewilding endeavor across 7,000 square kilometers of northeast Argentina's Corrientes Province.[347 348 349] A jaguar reintroduction program started in 2015 first bore fruit in 2018 when two new wild jaguar cubs were born in the newly formed Iberá Park, the first in decades.[350 351] Reintroductions of the red and green macaw started in 2015 with just 15 birds, and by 2020 they had successfully raised wild chicks for the first time in 150 years.[352 353] Formerly extinct throughout Argentina, the return of this charismatic species – an important seed disperser for many plant species – is a further mark of the program's success, and builds on similar success for other iconic species, such as the giant anteater.

Chile: Rewilding with Ranchers

Patagonia's 1.6 million square kilometers of temperate grasslands spread across Argentina and Chile and support a unique ecological and cultural heritage. The ecosystem provides many important services, such as clean air and water, forage for livestock, carbon sequestration, and wildlife habitat. In 2004, the NGO Conservación Patagónica set up by Tompkins, bought a 700-square-kilometer overgrazed sheep ranch in the Chacabuco Valley. Restoration efforts focused on the natural regeneration and the rewilding of native grasslands and wildlife, removing 25,000 sheep and 400 kilometers of fences. As a result, the native guanaco – a relative of the llama – population has increased from only several hundred to more than 3,000 today. The project supported ranchers in the adoption of sustainable grazing and grassland management practices, along with ecotourism infrastructure that now includes a lodge, restaurant, campsites, visitor center, and museum, and 250 kilometers of hiking trails.[354] In 2018, in the largest donation of private land to a government in South America, the Patagonia National Park was handed over to the Chilean government as part of a network of five newly created parks.[355]

© Paul Augustinus

Europe: Take a Walk on the Wild Side

Wildlife in Europe has dramatically decreased over the last few millennia because of the extensive transformation of habitats and the resulting loss of species.[356] At least 1,677 species are currently threatened with extinction; some 36 species had become extinct as of 2015.[357] The concept of rewilding is now gaining traction across Europe.[358]

UK: Bringing Back the Beavers

While more majestic wildlife species have been suggested for rewilding in the UK – such as the descendants of Europe's wild ox (aurochs), wolves, or wildcats – several successful rewilding programs have focused on beavers.[359] They were hunted to extinction in the 16th century,[360] but are now being reintroduced in different areas, including Somerset,[361] Yorkshire,[362] Cumbria,[363] and Gloucestershire.[364 365] This shy animal is a prodigious aquatic engineer, contributing to flood risk reduction, water quality improvement, and biodiversity protection.[366] Beavers gnaw and fell trees, using the timber to construct dams that raise and stabilize river levels, increase the beavers' access to resources in flooded areas, and reduce their exposure to predators. By transforming erosional streams into depositional pond environments, beaver dams have positive effects on both aquatic and terrestrial biota and their trophic interactions, as well as to basin hydrology and water biogeochemistry.[367]

Netherlands, Romania, and the UK: Bison Reintroductions

European bison reintroduction programs in the Netherlands and Romania were declared successful in late 2020 after several years of conservation efforts.[368] As a result, there are now some 7,000 bison living in Europe, all descended from just 12 zoo animals, yet the species is still classed as vulnerable. In a Dutch project, which began in 2007, rewilding took place in a coastal dune area where forest patches are interspersed with open grasslands and scrubland.[369 370] In Romania's Carpathian Mountains, a project which started with 10 bison in 2016,[371] now has the largest free-ranging population in Europe with over 100 individuals.[372] Efforts are being made to replicate their success elsewhere in Europe. For example, in the UK, a project starting in 2022 will use an initial herd of four bison to rewild a former commercial pine forest.[373] Bison are often referred to as 'landscape architects' and 'natural firefighters', performing essential functions of protecting biodiversity, both flora and fauna, in vast areas of forests and meadows.[374] Additional environmental benefits have been realized by bison grazing jointly with other fauna like Konik horses, highland cattle, deer, and rabbits.[375]

Bulgaria/Greece: Lords of the Rhodopean Skies

The Rhodope Mountains in Bulgaria and Greece are one of Europe's biodiversity hotspots and a vital breeding area for critically endangered griffon and black vultures. The griffon was once widely distributed across Bulgaria, but by the early 1970s it was thought extinct. However, in 1986, a relict griffon vulture population was discovered clinging on in the eastern Rhodope Mountains, consisting of about 20 birds and three nesting pairs.[376] While vultures are often portrayed as mere scavengers, they have an important function of 'cleaning up after death', helping to keep ecosystems healthy.[377] Over the last five years, the rewilding initiative LIFE Vultures,[378] in the mountainous border area straddling Bulgaria and Greece, has helped stabilize and increase vulture populations by improving the availability of natural prey (e.g., restoring food webs), and by reducing mortality due to illegal hunting, poisoning,[379] and collisions with power lines.[380] The griffon population is recovering quickly: compared to 2016, when 81 pairs were registered, by mid-2020 there were 111.[381]

Italy: Marsican Brown Bear

The Marsican brown bear is a unique subspecies of brown bear only found in a limited area of the central Apennines, where just 60 individuals are thought to remain.[382] After surviving for millennia in a relatively small territory, the bear population has been threatened by humans for centuries, mainly due to poaching, and the species is currently classified as critically endangered.[383] The Rewilding Apennines Initiative is focused on protecting and boosting the bear population by developing wildlife corridors and nature-based economies to promote a harmonious human-wildlife coexistence.[384] Five corridors now exist, covering over 1,000 square kilometers in three protected areas and their buffer zones (the Abruzzo, Lazio and Molise National Park, the Majella National Park, and the Sirente Velino Regional Park). The corridors are monitored using camera traps and field observations made by staff and volunteers. In addition, there have been efforts to improve food sources, remove fencing, and undertake clean-up initiatives. Over the last four years the number of bear cubs born has increased, with the highest numbers in the Abruzzo, Lazio and Molise National Park.[385]

Keeping Drylands Working

Drylands cover 46% of the Earth's terrestrial surface, play a critical role in global ecosystem function, and are home to over two billion people. They are defined as areas where the aridity index (the ratio of total annual precipitation to potential evapotranspiration) ranges between 0.05 and 0.65, and include arid, semi-arid, and dry sub-humid regions. The lack of water limits both vegetation growth and soil moisture, often resulting in landscapes with low productivity and plant cover as well as young soils with little organic matter. Like other biomes, drylands face increasing pressure from humans and climate change. Many of these ecosystems are close to tipping points, which, if crossed, can lead to abrupt transitions and persistent degraded states (e.g., desertification).[386] Sustainable land and water management practices are key to keeping drylands functioning – critical to mitigating climate change, reversing desertification trends, and improving livelihoods for one in three people on the planet.

South Africa: Working for Ecosystems

Across South Africa, four centuries of colonialism, mining, and ranching have taken a toll on the extensive drylands and their often highly biodiverse and endemic flora. In recent decades, the South African government has launched a number of large-scale programs to support rewilding and improved management of these fragile ecosystems. In 1995, the government launched a multi-departmental Working for Ecosystems program, combining natural resource management with poverty relief, employment, and other development opportunities to herald the post-apartheid era.[387] With an initial USD 7 million budget, the program has continually evolved, adding NGO and donor partners, scaling up to an annual expenditure of USD 80 million. It employs labor-intensive and 'trade, not aid' methods, which target unemployed, women, and youth. Since 2016, an average of 48,000 people each year have been employed in land restoration.[388] National Qualifications Framework training is compulsory for participants in the program and offers certification in terrestrial and aquatic clearing, bio-control techniques, health and safety measures, and educational attainment.

The Succulent Karoo Ecosystem Programme in Namaqualand covers nearly 120,000 square kilometers and is centered on one of only two arid biodiversity hotspots in the world, where some 40% of its resident species are found nowhere else.[389] Pastoralism is the main use of land, and decades of overstocking and cultivation has led to extensive land degradation and soil erosion, particularly in communal areas.[390] Restoration activities include low-cost, labor-intensive soil stabilization measures, such as installation of stone packed gabions (metal cages), and the creation of ponds to increase water infiltration to reduce run-off, increase sediment capture, and promote vegetation cover. Over its 20 years of operation, 5,000 square kilometers have been restored and better managed, and the area of land formally protected has doubled.

The Subtropical Thicket Restoration Programme in the Eastern Cape is focused on restoring degraded spekboom thicket landscapes by planting the indigenous tree, Portulacaria afra, also known as spekboom. The vision is to restore the more than 1 million hectares of degraded spekboom thicket in this region. The degradation of the thicket occurred as a result of overbrowsing by goats and has reduced the carrying capacity of the landscape by more than ten-fold in many areas. The program is running in partnership with farmers, communities, government, scientists, and economists. Over 300 quarter-hectare experimental plots were set up in the Eastern and Western Cape in 2008, which today provide evidence of the efficacy of the restoration over the full extent of spekboom thicket.[391] It is anticipated that carbon finance will restore large tracts of the degraded land because more than 100 tonnes of carbon per hectare can be captured through the restoration process.[392] Preventing farmers from destroying the thickets and relict natural habitat on large ranches is another important aspect of the program. Analysis of a range of spatial and cadastral data is used to assess the extent and nature of destructive actions, including national vegetation, land cover, protected area and contour line maps, and recent satellite imagery. Warning letters – sent by police to landowners reminding them of the law protecting thicket, and the use of fines – are accompanied by maps showing recent satellite images, farm borders, and the total extant thicket or forest.[393]

New Caledonia: Recovering Tropical Dry Forest

The dry tropical forest of New Caledonia is a unique ecosystem, yet by 2000 it was dangerously close to disappearing, mostly converted to livestock production.[400] In 2001, a public-private partnership was established to protect the remaining fragments and restore deforested areas using exclosures for natural regeneration as well as planting programs for native species. Over 17 years, almost 180,000 saplings were planted, often through campaigns involving schools and local community groups. [401] [402] [403]

Brazil: Preserving the Caatinga Biome

The vast semi-arid Sertão region in northeast Brazil covers almost one million square kilometers, including the Caatinga biome, a biodiversity hotspot with an exceptional number of endemic species.[394] Despite its recognized status, this dryland ecosystem is increasingly threatened by land degradation and desertification, driven by climate change and vegetation losses due to charcoal production, poor farming practices, deforestation by smallholders and ranchers, resource extraction, and unsustainable irrigation practices.[395] Between 2004 and 2010, the Sertão Project aimed to address these causes and protect the Caatinga biome by implementing sustainable land use systems.[396] Efforts included cotton production by agroecological partnerships using sustainable irrigation, the organization of community vegetable gardens and orchards, planning of Agrarian Reform Settlements, and raising environmental awareness through training activities, farmers' exchanges, and the creation of demonstration units.[397]

These activities have reduced soil and fire threats and improved water use efficiency on about 200 square kilometers. The area also saw an 11% increase in species diversity, a 69% reduction in erosion, and increases of between 15% (Piauí state) and 79% (Pernambuco state) in carbon sequestration. The Sertão project helped improve the lives of almost 12,000 families through better management of natural resources, increasing family incomes by between 50 and 200%.[398] Planning and training, access to regional organic and fair-trade markets, and the setup of a farmer-led organic certification system[399] have all contributed to better awareness of the benefits of conservation and improved land management based on agroecological principles.

Pakistan: Desertification Control through Sustainable Land Management

Productive land is scarce in Pakistan – 80% of the country is arid or semi-arid. Land degradation and desertification are caused by unsustainable land management practices, coupled with increased demand for natural resources, and driven by a rapidly growing and largely rural population dependent on drylands for their livelihoods.[404] To address these problems, in 2007, the Pakistani government began implementing a Sustainable Land Management program across nine dryland districts. Over eight years, 120 square kilometers of degraded rangeland were rehabilitated through reseeding and community-based grazing management, and a further 80 square kilometers under sustainable rainfed agriculture and water conservation measures.[405] In 2015, the project was extended and rolled out more widely, utilizing water control and storage structures, creating shelterbelts and rangeland management plans, restoring degraded dryland forest (e.g., community tree nurseries and plantations for domestic fuel), and implementing sand dune stabilization measures. As a result, some 13,000 households directly or indirectly benefited from nearly 200 square kilometers of improved land health, better access to water for livestock, and reduced wind erosion.[406]

This success of the program inspired the Billion Trees Afforestation Project in Pakistan's mountainous Khyber Pakhtunkhwa, which saw 3,500 square kilometers of forests and degraded land restored in just two years.[407] [408] Strong engagement with local communities was a key success factor.[409] The restoration target was achieved through both natural regeneration (60%) and planned afforestation (40%).[410] In addition to significant income and job generation,[411] [412] the Khyber Pakhtunkhwa government also surpassed its 3,484 square kilometer commitment to the Bonn Challenge,[413] becoming the first such commitment to be fully met.[414] In 2018, the popularity of this initiative gave impetus to the world's largest reforestation initiative — the Ten Billion Tree Tsunami Programme – as part of a suite of nature-based solutions to fight desertification and climate change in Pakistan.[415]

Australia: Indigenous Rangers Combating Desertification

Indigenous Rangers are leading efforts to combat desertification across much of Australia's vast territory. The Indigenous Protected Areas (IPAs) Program, launched in 1997, and the Working on Country Indigenous Ranger Program, launched in 2007, empower indigenous communities to control and halt the spread of land degradation and desertification. Both programs give indigenous groups free rein to determine their own goals and methods, averting the loss of trust that has plagued more prescriptive policies. IPAs represent a contract for the management of environmental and cultural values between traditional owners and the federal government and are made operational only after a management plan has been developed by indigenous partners. Almost 70,000 square kilometers have so far been dedicated as IPAs, creating the world's most extensive arid land protected zone. The Ranger Program provides employment, helps revive the skills of indigenous people, and utilizes both indigenous ecological knowledge and modern science to conduct traditional fire and water management and control invasive species. There are also mechanisms in place to allow indigenous communities to claim and sell carbon credits. The success of these programs has been credited to the high-value assigned to indigenous knowledge and priorities, a strong connection to land, flexible working arrangements that allow for family and cultural commitments, and the trust built through long-term funding arrangements.[416]

Protecting and Restoring Peatlands

Worldwide, peatlands have been drained for centuries to create new agricultural land, access fuel, or as a source of timber and building materials. The draining of peatlands lowers both ground water and land surface levels, releasing large amounts of greenhouse gases up to 1,500 tonnes of CO_2e per square kilometer each year.[417] Shrinkage, drying, and loss of vegetation in degraded peatlands make their soil susceptible to wind erosion, leaving them more vulnerable to wildfires, which are increasing in their frequency, extent, and duration, often with wide-scale impacts. Given their small extent yet outsized impact on the global climate system, maintaining or enhancing the resilience of intact peatlands, and rewetting or restoring degraded peatlands is recognized as a cost-effective and practical solution to help mitigate against climate change.[418]

Belarus: Rewetting Drained Temperate Peatlands

Belarus is rich in peatlands, covering 25,000 square kilometers, home to over 35% of bird and insect species and over 15% of wild plant species.[419] [420] Nearly two-thirds of the peatlands were drained for food production during the Soviet era, but are now abandoned with devastating environmental and climate consequences. Drainage is estimated to have reduced ground water levels by around 50 centimeters, making them prone to increasingly intense wildfires.[421] In the south of Belarus, the region most affected by higher temperatures and reduced soil moisture, the number of recurring peat fires increased from 17 in 2017 to 121 in 2019, many of which occurred within zones still contaminated by radioactivity from the 1986 Chernobyl disaster,[422] [423] posing a significant threat to public health as radioactive dust and ash is dispersed widely.[424]

Between 2018 and 2021, the Korean Forest Service, through the UNCCD's Greening Drylands Partnership, funded the rehabilitation of nearly 40 square kilometers of degraded peatlands in eastern and southern Belarus (within the Chernobyl radioactive zone) to drastically reduce the incidence and impact of wildfires. The project team customized the Verified Carbon Standard methodology for Rewetting Drained Temperate Peatlands to calculate carbon emissions reductions from restored peatlands, enabling Belarus to trade credits in voluntary carbon markets. In 2019, Belarus adopted a Law on the Protection and Use of Peatlands to support efforts to achieve land degradation neutrality targets under the UNCCD and improve biodiversity values.[425] The law approved the list of peatlands subject to ecological rehabilitation, with a total area of more than 1,400 square kilometers.[426] Their rewetting will contribute to the Paris Agreement, under which Belarus pledged to reduce greenhouse gas emissions by at least 35% by 2030. Eco-trails in the restored mires and bogs provide educational and tourism opportunities, generating jobs and local income.[427]

Indonesia: Rewetting, Revegetation and Revitalization

Indonesia has over 140,000 square kilometers of biodiverse and carbon-rich peatlands across the lowlands of eastern Sumatra, southern Kalimantan, and western New Guinea.[428] Up to half has been disturbed – drained, logged, burned, or converted into rice fields or oil palm plantations.[429] Seasonal and deforestation wildfires in the region frequently result in a toxic haze that blankets large parts of southeast Asia.

North America and Ireland: Private Sector Collaboration

In North America and Ireland, peatland restoration has often involved a close collaboration between the peat extraction industry and scientists to develop best practice approaches. In both countries, the rationale for restoring peatlands has expanded to include legal requirements, wetland mitigation and banking, climate and flood mitigation, water quality, and as a part of responsible ecosystem management by industry.[430] In Canada, peat extraction to produce horticultural substrate from the upper layers of peat makes restoration relatively easier. In the USA, industrial-scale agricultural drainage is responsible for much of the peatland loss, most notably along the Mississippi River. Recent catastrophic flooding events, however, are forcing a reassessment in which peatland restoration now forms part of an integrated flood management approach.[431] In 2021, Ireland rehabilitated nearly 5,200 hectares of peatland, employing many former peat workers involved in harvesting and transport to transform degraded peatlands into fully functioning wetlands.[432]

In the 2015 fire season, fires across Indonesia emitted more carbon dioxide each day than the entire US economy.[433] More than half of these fires occurred on peatlands, causing an economic loss of USD 16 billion, not including the loss of ecosystem services or regional impacts.[434]

National efforts to halt peatland degradation were bolstered in 2011 when the government announced a moratorium on the clearing of primary forest and the conversion of peatlands, which was further extended in 2017.[435] In 2016, a Peatland Restoration Agency was established to follow up on the commitment to restore a minimum of 20,000 square kilometers of peatlands by 2020,[436] as part of a national plan to reduce carbon emissions by 30% by 2030.[437] Not yet widely utilized in the tropics, the sustainable use of peatland by paludiculture – the growing of crops or harvesting of aquatic animals under conditions of zero drainage – shows great promise.[438] [439] Another valuable response measure involves the ecological restoration of degraded peatlands following the 3R approach – Rewetting, Revegetation, and Revitalization of local livelihoods.[440]

It was this 3R approach that underpinned the central Kalimantan Peatlands Project in 2005,[441] [442] seeking to maintain and restore peatlands in the Sebangau National Park and parts of the former Mega Rice Project.[443] [444] Implemented by five local bodies, the project focused on improving hydrological functions, regreening degraded peatlands, and reducing fire risk and damage. Sustainable agricultural techniques were also introduced to improve local socio-economic conditions. These activities, which covered 100 square kilometers in the park and over 500 square kilometers of former rice fields, raised the water table by one to two meters and greatly reduced peat decomposition and subsidence. Wildfire occurrences were slashed in number and any outbreaks were more rapidly detected and controlled. Ten square kilometers have been reforested, enhancing Sebangau National Park. Enforcement of logging restrictions was supported by local communities that participated in the design and planning of conservation and restoration efforts. By the end of 2020, over 8,000 square kilometers were restored – 94% of the project's target.[445]

2.3.3 FOREST AND LANDSCAPE RESTORATION

Forest and landscape restoration (FLR) is the process of regaining ecological functionality and enhancing human wellbeing across deforested or degraded forest landscapes.[446] The Bonn Challenge and associated regional initiatives have mobilized political support to commence restoration on 1.5 million square kilometers of forest landscapes by 2020 and 3.5 million square kilometers (larger than the size of India) by 2030. The FLR approach differs from ecological restoration in that equal priority is given to human livelihoods and biodiversity conservation.[447] The broad principles focus on landscape integrity (i.e., a mosaic of ecosystems), stakeholder participation, and restoring multiple ecological functions for multiple benefits using context specific approaches.[448] As FLR is a relatively new approach, there is a lack of robust case studies, although promising examples are emerging.[449]

Costa Rica: Regenerating Forest Landscapes

After rapid growth in crop and livestock production, by the 1970s Costa Rica was suffering from considerable forest and widespread land degradation. In response, the government started a program to protect natural areas, initiating a network of national parks which would be consolidated decades later.[450] After the 1992 Earth Summit, a new Forestry Law prohibited land use change, and created a Payment for Environmental Services (PES) program financed by a fossil fuel tax. In 2002, the country's first UNCCD National Action Programme (NAP) prioritized rehabilitating degraded areas, then estimated to cover 60% of the country. These incentives – along with political will, strong environmental governance, and support from the Costa Rican people – led to the recovery of forest land with 52% coverage by 2014, fast approaching a target of 60%.

One NAP project has prompted sustained restoration activities in the Jesús María river basin in Costa Rica's Central Pacific region. Ranging from the Pacific Ocean to 1,500 meters in altitude, the basin is home to 20,000 people across 350 square kilometers. With investments of over USD 2.5 million since 2011, farmers have restored forest areas and ecosystems using sustainable soil and watershed management practices. An associated PES program covers an even wider range of conservation measures and regenerative agricultural practices across 150 square kilometers, ensuring improved access to water and increasing productivity in coffee and other agroforestry systems. More than 6,500 people (40% of which are women) have improved their knowledge and use of these practices.[451] Today, not only have the basin's most degraded areas been rehabilitated, but the initiative has served as an operational model for neighboring communities.

Vietnam: Market-based Agroforestry Landscapes

Northwestern Vietnam is mountainous and one of the country's poorest regions, inhabited mainly by tribal minority groups. Local agriculture often features extensive monocropping of maize without proper conservation measures. On steep slopes, this leads to soil erosion and an over-reliance on chemicals fertilizers. A consortium of partners proposed an agroforestry approach to address these problems and contribute to Vietnam's commitments to climate and biodiversity. After a stakeholder consultation, a provincial agroforestry strategy was implemented to promote sustainable livelihoods adapted to the customs and behavior of different ethnic groups.[452]

The first steps piloted different interventions and trialed approaches to integrating forests and agroforestry, aiming to understand the ecological and economic impacts, and develop markets and policies to scale up adoption. Six pilot plots of 50 hectares were set up, with private sector collaboration creating infrastructure and downstream markets for produce. Farmers' groups, cooperatives, and extension workers were trained in agroforestry techniques and assisted in negotiating prices with traders. In addition, assisted natural regeneration and tree planting programs restored natural forest areas. After seven years, these plots, intercropping longan trees and forage grass with maize, generated a three-fold increase in average annual incomes – even after relatively high set up costs. Environmental benefits included greater soil water retention, reduced surface runoff and soil erosion, and increased soil fertility. After 20 years, the program estimated a net present value of maize-based agroforestry at USD 30,000-55,000 per hectare, compared to USD 6,000 per hectare for maize monocultures.[453]

Democratic Republic of the Congo: Yangambi Engagement Landscape

Following decades of instability and conflict, Yangambi, a once lush rainforest landscape in northern Democratic Republic of the Congo (DRC), was severely degraded and largely abandoned. Former plantations of commodity crops converted to subsistence farming continued to suffer from poor agricultural practices, which lowered soil fertility and threatened local livelihoods.[454] The Yangambi is now being regenerated, using sustainable land management practices with technical and financial support for activities like beekeeping and animal breeding. The planting of the millionth tree in April 2021, after just three years of work, marked a key milestone towards a goal of restoring 20 square kilometers of land by 2022.[455] The Yangambi Engagement Landscape project has focused on job creation, employing 1,800 people in various roles, ranging from seedling propagation in nurseries to guarding trees against bush fires. This has generated additional income and many locals have started small businesses. Despite the use of small solar panels to power basic appliances across the region, the continued reliance on firewood for fuel remains a great challenge to sustainable development. By integrating acacia trees with better quality cassava, farmers can obtain higher yields and, after six years, begin to harvest wood for energy. As part of the AFR100 initiative, the DRC has pledged to restore 80,000 square kilometers of land by 2030, and engagement landscapes like Yangambi will be key to achieving this goal.[456]

Brazil: Restoring Tropical Savanna

The Cerrado is the second largest biome in Brazil at around two million square kilometers, and the most biodiverse tropical savanna in the world – a mosaic of grasslands, scrub, woodlands, and riparian habitat. In recent decades, approximately half of the Cerrado's native vegetation has been destroyed by mining, cattle ranching, soy, cotton, and other agribusiness concerns. Deep-rooted ecosystems have been replaced with shallow-rooted monocultures.[457] Since 2010, a collaborative network (Restaura Cerrado) has brought together scientists, seed collectors, and the public to advance practical knowledge about savanna restoration.[458] The network has raised awareness of the value of restoring native grasses and shrubs, removing invasive species, and resisting an impulse to plant trees everywhere.[459] The sourcing and supply of genetic material – seeds – is critical to savanna restoration. Restaura Cerrado works directly with families, training them to collect and prepare seeds to sell to partners carrying out restoration activities. In one project, seed harvesters founded a cooperative which is now self-sustaining, generating income to improve livelihoods and drive a restoration economy.[460]

Rwanda: Private Forests Management Units

In Rwanda, demand for wood – largely for domestic fuel – exceeds supply and causes significant forest degradation and loss.[461] Over two-thirds of forest land belongs to private smallholders,[462] but is often poorly managed and over-exploited. In 2019, Private Forests Management Units (PFMUs) were established to help smallholders plant, harvest, and better manage forests and agroforestry plots, increasing timber and fuelwood supplies while diversifying incomes. Enabling activities included the formation of cooperatives composed of private woodlot owners, community vigilance committees to manage roadside/riverside plantations, and farmer field schools to demonstrate the value of extension services. PFMUs contribute to Rwanda's LDN targets by rehabilitating degraded forests, in alignment with the National Strategy for Transformation (2018-2024), National Forest Policy, and Forest Sector Strategic Plan (2018-2023).[463] Two key objectives of these strategies are to increase GDP and support rural employment, particularly for women and youth.

Rwanda's seven-year Forest Sector Strategic Plan (2018-2024) has a budget of USD 82 million,[464] which includes public funds, donor grants, and loans from multilateral development banks. This blended investment strategy is vital to support reforestation efforts, which cost around USD 500 per hectare. PFMUs have already been implemented in seven districts with individually owned plots, grouped into consolidated business enterprises of between 30 and 50 hectares. Preliminary analysis shows promising improvements in soil fertility, erosion control, water regulation, and carbon sequestration. Turning patchworks of privately owned forests into cooperative business enterprises is contributing to the restoration of degraded forests in Rwanda. The 870 hectares which have been restored is expected to increase the project's wood supply capacity and smallholder incomes eight-fold over the next two decades.

Andean Region: Restoring Forest Watersheds

Evergreen forests in the mid- and high-elevation Andes form important habitats for wildlife and biodiversity. Helping to ensure the functionality of the entire Amazon basin, they also serve as water sources for large urban areas. As a result of widespread regional deforestation and overgrazing, just 5,000 square kilometers remain intact. Acción Andina, powered by Global Forest Generation, is now scaling up a widely used community reforestation model that has already planted over three million native trees. Its success is attributed to a network of experienced community leaders across the Andes, each with

long-term trusted relationships and a deep cultural understanding. The project involves developing basic leadership and conservation management skills and equipping organizations to scale up their restoration activities. Conservation partners in each country (**Argentina**, **Bolivia**, **Chile**, **Colombia**, **Ecuador**, and **Peru**) support communities to secure titles to their land, reinforcing a cohesive identity and providing legal protection from exploitation by timber, mining, or fossil fuel companies. When initiating the process of designating a protected area, partners help resolve land use disputes, establish land use agreements, and develop long-term conservation plans, including access to native seed stocks for reforestation. Acción Andina is supported by a mix of donations, private investments, payments for ecosystem services, and multilateral funding. While long-term finance is vital, the success of its model depends largely on a decentralized social and cultural movement.[465]

Bhutan: Community-based Forest Management

In Bhutan and many parts of Asia, a vicious cycle of land degradation leads to more pressures to increase food production, which in turn leads to further expansion of agricultural land into forests. Bhutan's constitution mandates that at least 60% of the country must be forested 'for all times to come'. An innovative community-based forest management policy is taking shape to resolve the land use conflict between migratory pastoralists and sedentary farmers in remote areas. New decentralized policies embrace ecosystem protection and restoration by prioritizing the participation of local communities. This includes the management of planted forests and the designation of transhumance corridors for animals so that water resources are not polluted by yaks and cattle, a primary source of conflict.[466] While the value of planted forests is perceived to be lower than that of natural forests, soil erosion, land degradation, and fuelwood shortages have all been significantly reduced as have pressures on relict natural forests.

While newly planted forests will eventually yield important timber resources, residents often point to the suite of ecosystem services they enjoy as the stands mature, including non-timber forest products, water regulation, disaster risk reduction, and social and aesthetic values. By empowering people with a direct stake in forest resources to be part of decision-making, their views contribute to shaping policy. The notable success of forest management in Bhutan has been very much dependent on local community participation.[467] Bhutan's commitment to protecting its biodiversity and associated traditional knowledge was further underpinned in December 2021 by the adoption of new laws to strengthen the focus on the conservation and sustainable use of biodiversity.[468]

Restoring Forest Landscapes with High-Value Crops

While the cultivation of coffee, cocoa, vanilla, and other high-value crops provides a good livelihood for many smallholders, it is also a significant driver of deforestation and land use change in many tropical countries.[469] Agroforestry systems on deforested lands, in which these crops are combined with shade trees, are considered to have great potential for biodiversity enhancement and ecologically sustainable cultivation.[470] [471] It is also possible to integrate sustainable harvesting, forest management, and livelihood strategies by 'farming the forests'.[472] Certification standards and sustainability labels are required to ensure nature-positive outcomes and avoid plantations that degrade healthy, intact forests.[473]

Côte d'Ivoire: Cocoa and Zero Deforestation

Intensive cocoa production in Côte d'Ivoire, the world's leading cocoa producer, has decimated forest cover. To arrest and reverse this trend, the country has adopted a 'zero deforestation' agricultural policy and committed to rehabilitating its forest cover by planting high-value native tree species in cocoa landscapes, using a participatory approach. This involves encouraging cocoa farmers to engage with the rehabilitation plans so that a truly biodiverse cocoa agroforestry ecosystem can be established. A core facet of this strategy is to develop an accessible database of potential species, specifying the benefits that farmers can expect from trees, including edible and marketable products. Farmer training and tree nurseries will be essential to meet household needs and market preferences through a blend of products and services from different tree species that optimize economic and environmental benefits.[474]

Brazil: Agroforestry Cooperative Reforesting the Amazon

In a remote northwest region of Brazil (Nova Califórnia, Rondônia), in 1989, a group of 86 farming families set up a unique cooperative enterprise that plants native fruit trees on former ranching estates. Known as RECA – the Consortium and Densified Economic Reforestation Project – the farmers continue to reforest their land in a way that mimics the natural habitat.[475] RECA's farmers work to re-establish ecosystem functions and services by densely planting up to 40 native species of fruit, timber, and medicinal species on their rainforest parcels. Currently, 35 properties have organic certification for high-value products, such as cupuaçu and açai pulp, palm hearts, and andiroba or Brazil nut oil. Over 300 RECA families now earn about five times more per hectare annually from their agroforestry plots than local ranchers do from pastures. RECA's sustainable

agroforestry business model provides a future vision and a stark contrast to cattle ranching, which is a leading cause of deforestation in the Amazon.[476]

Mozambique: Coffee in Gorongosa National Park

Once threatened by civil war, today the vast and densely populated Gorongosa National Park in Mozambique is being restored with the help of shade-grown coffee and other high-value agroforestry crops.[477] Gorongosa Coffee is a globally recognized brand associated with conservation and regenerative agriculture that employs indigenous people and local communities. Since 2004, agroforestry techniques have greatly enhanced biodiversity values in Gorongosa, one of the best studied protected areas in Africa. In addition to conservation efforts and local wildlife rangers to curtail illegal poaching and harvesting, there are currently some 5,000 smallholders directly benefiting from coffee, honey, and cashew programs. They receive production inputs and technical assistance and enjoy stable and fair markets in which to sell their products.[478] By 2025, Gorongosa Coffee aims to have planted and regenerated a total of 10 square kilometers with shade-grown coffee, as part of a program to restore 80 square kilometers of rainforest, using coffee production as the catalyst for scaling up regenerative agricultural practices.

Kyrgyzstan: Regenerating Walnut Forests

The walnut forests of southern Kyrgyzstan form an important biodiversity hotspot – many familiar domesticated varieties of fruits and nuts originated in the region. Today, walnuts are a major source of income for many households in the region and provide jobs for over 16,000 people.[479] However, over-exploitation and poorly managed grazing, exacerbated by land use conflicts and a lack of community involvement in decision-making processes, have hindered natural forest regeneration.[480] [481] A three-year-long community-based project was implemented in Bazar-Korgon in 2018, home to 130 square kilometers of natural walnut forest – the largest in the world where the forests are interspersed with pastures and highlands, and are home to nearly 50,000 people.[482] The project involved: capacity building for state agencies and local communities to establish a joint management model; sharing of information, best practices, and innovation around sustainable land use and gender integration; improving local livelihoods by generating income from non-timber forest products; and raising awareness of environmental issues.[483] Participatory forest and pasture management activities were jointly carried out by users and forest enterprise staff, including pilot programs and business planning to strengthen value chains and unlock ecotourism opportunities.

Thailand and Indonesia: Restoring Degraded Land with Rubber Agroforests

In northeast Thailand, smallholders are rehabilitating highly degraded cassava fields by planting rubber agroforests. Rubber can be grown in combination with fruit trees (e.g., mangosteen), shade crops (e.g., tea, cardamom), or within multi-species systems incorporating high-value timber species that mimic secondary forest regrowth. With global demand for rubber strong, this method of agroforestry has the potential to rehabilitate ecosystem services over 50,000 square kilometers of degraded monoculture plantations elsewhere in southeast Asia. For example, at Hutan Harapan, an Ecosystem Restoration Concession in Sumatra, Indonesia, rubber agroforestry is being used as a community development tool to reduce land conflicts and avoid further deforestation.[484] [485]

Ghana: Sustainable Palm Oil

In 2009, Dr. Bronner's, a global cosmetic soap brand, made the commitment to only source regenerative palm oil and initiated the Serendi palm oil project in Ghana.[486] It began with around 500 smallholders who were already growing oil palm on small plots (averaging under two hectares), surrounded by similar plots of cocoa, citrus, maize, and cassava. No primary or secondary forest was felled to establish new plots. After a first phase, in which the oil palm farmers secured organic certification and were paid fair-trade prices, they transitioned towards regenerative practices. In 2016, the concept of dynamic agroforestry (DAF) was introduced, which involved planting cocoa, oil palm, and other timber and fruit trees in stratified mixed cultures. DAF simulates the succession of trees in natural tropical forests and optimizes the utilization of sunlight and soil microbes. Much higher planting densities increase cocoa and oil palm yields up to three times compared to monocultures. Continuous output throughout the year helps smooth annual farm income and improve food security, while improved biodiversity reduces pest problems and higher tree growth rates sequester more carbon.[487]

Kenya: Honey Care Africa

Honey Care Africa is a Kenyan social enterprise that has been raising incomes for rural farmers through apiculture since 2000. Taking advantage of a tradition of beekeeping as a supplementary source of food and income for farmers, the enterprise has sought to improve the image, productivity, and viability of beekeeping and demonstrate its value as an alternative to poaching or charcoal production for poor rural communities. The Bees for Trees program provides beehives and equipment to farmers in exchange for forest preservation practices in the areas where hives

are located. A USD 250 average increase in annual household income resulted from honey sales, and crop yields increased as bees improved their pollination rates. Farmer surveys have found that honey production revenues are spent in numerous ways: 33% on food and medicine, 25% on seeds and fertilizers, 18% on school fees, 10% on improving housing, and 5% on launching micro-enterprises.[488]

Guatemala: Sustainable Honey and Cocoa for Local Livelihoods

In the last 40 years, Guatemala has lost almost half its rainforest. The project ForestValues – Innovative Partnerships for Forest Restoration partners with local communities to design and implement forest conservation and restoration projects in the Sierra del Lacandón, Sierra de las Minas, and Bocas del Polochic. To generate income for local communities, they are supported to produce, process, and sell honey, cocoa, or breadnut. Beehives can be integrated into many existing agroforestry systems, improving pollination rates and crop yields. Increases in beekeepers' income and family consumption of honey are key positive outcomes. Improved management and agroforestry practices, including planting of native timber species on cocoa farms established a generation ago, have resulted in five-fold increases in production. Small investments helped set up an independent, revolving credit fund for small farmers' organizations to bridge income gaps between harvesting, processing, and selling cocoa beans. This income support gives farmers the ability to respond to market conditions and obtain the best prices for their fermented and dried raw cocoa beans, without impacting family food security.[489]

Morocco: Argan Oil to Conserve Dryland Forests

The Argan tree is native to southern Morocco and a key species in a forest ecosystem that covers about 2% of the country's land, providing habitat for a wide variety of wildlife species. Over the last century, the area covered by Argan trees has shrunk by half due to intensified land use, such as plantations of water-intensive citrus trees. L'Oréal, the international cosmetics firm, established a program to sustainably source Argan oil to ensure a fair return to local communities, conserve local biodiversity, and reassure consumers by certifying the traceability and quality of the oil. Another important L'Oréal objective was to agree on patent use of raw materials, so that novel uses of the oil were distinguished from traditional ones, and access to Argan oil for indigenous communities was not disrupted. In addition to improving the quality of life for female workers and their families, the program has contributed to the economic and social development in the area. Today, there are over 200 women working in six production cooperatives, one extraction and oil facility, and 15 preparation cooperatives. The program has also increased community awareness of the value of the Argan forest ecosystem, which incentivizes its conservation.[490]

© Thomas Cristofoletti_USAID

Coffee Agroforestry for Forest and Landscape Restoration

Despite the wide promotion of agroforestry systems as a sustainable land use, little is known about its potential in ecosystem restoration. A 2020 study compared ecological outcomes after 15 years of two types of restoration interventions – coffee agroforests and diverse restoration plantations – with those of reference old growth forests in the Pontal do Paranapanema region of southeastern Brazil. It compared the abundance, richness, canopy cover, and species mix across the three forest types. Reference forests had a higher abundance of trees and regenerating saplings, but had similar levels of species richness compared to coffee agroforests. High-diversity agroforests and restoration plantations did not differ in tree abundance but, compared to restoration plantations, agroforests showed higher abundance and species richness in regenerating saplings, a higher proportion of animal-dispersed species, and more extensive canopy cover.[491]

A 2021 study that analyzed 77 sites in West Africa and the Americas reinforces the evidence base for synergies between agroforestry and restoration. It showed that tropical forests have enormous potential to regrow naturally on abandoned lands, and after 20 years of low-intensity land use, could attain close to 80% of species richness compared to reference old growth forest.[492] To conclude, coffee agroforestry systems can reconcile long-term forest restoration outcomes with sustainable agricultural production in tropical forest regions. These systems provide a cost-effective and viable alternative to ecological restoration within agricultural landscapes when managed by and for local communities.[493]

Indonesia: Illipe Butter Helping to Protect the Rainforest

Over half of the Borneo rainforest in Indonesia has been lost in the past 50 years, and this destruction has had disastrous effects on local people and wildlife, including orangutans. Forestwise is a social enterprise dedicated to protecting the rainforests of Borneo. Working together with local forest communities, Forestwise developed a market for high-value, sustainably harvested products. One example is illipe butter, made from the nuts of the endangered Shorea stenoptera tree, which only grows in the forests of Borneo and Sumatra. Many of these trees have been felled for timber and pulp or to make space for monoculture plantations, usually oil palm. To create alternative sources of income for local communities and protect the rainforest, contracts to buy their illipe nuts were made with over 700 collectors from 25 villages in West Kalimantan. As a result, the total area covered by these villages (2,000 square kilometers) has delivered higher standards of conservation. Forest protection agreements with the four main villages supplying illipe nuts cover a core area of over 260 square kilometers.[494]

Bhutan: Restoring Degraded Land with Hazelnuts

About 70% of the population of Bhutan lives in rural areas, depending on subsistence agriculture. Yet less than 3% of the Himalayan country is considered arable land, and a large part of that is fragmented by land degradation. Partly in response to these challenges, Mountain Hazelnuts was created in 2009 as a business providing long-term income to vulnerable rural communities by planting 10 million hazelnut trees and helping to restore degraded mountain slopes. The company works with smallholder families and community groups (e.g., Buddhist nunneries, cooperatives) to provide additional income-generating opportunities that restore fallow and degraded land. To date, 100 square kilometers of land have been converted into sustainable hazelnut orchards, doubling incomes for 15,000 households, and sequestering between as much as eight million tonnes of carbon.[495]

Madagascar: Vanilla as a Restoration Opportunity

Currently, most Madagascan vanilla is grown in the Sava region, a northeastern tropical forest area with high annual rainfall. As a vine, vanilla orchids need supporting structures, like posts, fences, or tree trunks. Agroforestry efforts to grow vanilla in these forests and adjacent areas have benefited conservation efforts, since the low-impact plantations support and enhance biodiversity while producing high-value crops.[496] [497] [498] A 2020 study showed that plant diversity flourishes in vanilla plantations close to forest areas, offering endangered lemur species safe corridors between forest fragments, resulting in a more diverse and healthier population.[499]

2.3.4 NATURE-POSITIVE FOOD PRODUCTION

The term nature-positive can be applied to many approaches and practices used in food and commodity production and processing. Nature-positive food production is most efficient and effective when based on evidence, knowledge, and science that is adapted or tailored to local needs and conditions. There are many examples from around the world, from conservation and organic agriculture to integrated systems, such as mixed farming, agroforestry, aquaculture, and silvopasture.

> "Nature-positive food production is characterized by a regenerative, non-depleting, and non-destructive use of natural resources. It is based on stewardship of the environment and biodiversity as the foundation of critical ecosystem services, including soil, water, and climate regulation."[500]

The overarching goal of nature-positive food production is to maintain or enhance ecological processes and functions when producing food. Some of the most important functions are nutrient cycling, water retention, soil regeneration, carbon storage, nitrogen fixation, and the management of pest-predator interactions. The transition to regenerative food production in large-scale monocultures may be very different to that of smallholder and subsistence producers and may require longer timescales.

Cuba: The Farmer-to-Farmer Movement

The Campesino a Campesino (CaC, 'Farmer-to-Farmer') movement in Cuba shows how a social movement can scale up agroecological farming systems without central leadership or permanent funding. In Cuba, agroecology has long played a key role in helping the country survive limited international trade and occasional food security crises. Rural communities have been able to boost food production without scarce and expensive imported agricultural chemicals by using integrated and diverse farming systems.[501] The CaC movement began in 1997 as a series of programs run by the National Association of Small Farmers,[502 503] and by 2020, around 200,000 families – half of Cuba's smallholders – were participating in the Farmer-to-Farmer Agroecology Movement.[504] Now, up to 90% of Cuba's campesino farms use agroecological techniques from pest control to soil conservation.[505] The success of the CaC movement is due to its focus on local needs, knowledge, and environmental conditions, recognizing that smallholders are more likely to trust advice from their fellow farmers than from extension workers, NGOs, or agronomists.

Sri Lanka: Regenerative Agriculture in the Central Highlands

Small-scale farmers in the central highlands of Sri Lanka are battling land degradation, yet know little about alternative practices that are nature-positive and more profitable. Between 2015 and 2019, the Rehabilitation of Degraded Agricultural Land Project focused on governance and technology aspects of regenerative agriculture.[506] It developed participatory land use plans and demonstration plots for sustainable land management technologies on lands subject to severe degradation. Efforts focused on several different agricultural sectors and approaches.[507]

- **Dairy production.** Many smallholders have a small number of milk-producing cows, but dairy is rarely well integrated into other farm enterprises, such as vegetable production or tea cultivation. Training them on how to store and process manure for fertilizer has succeeded in reducing agrochemical usage and downstream pollution, while boosting crop productivity. Farmers also benefited from sales of excess manure, refurbished cowsheds, and higher milk yields.
- **Crop diversification.** Growing crops on steep slopes risks erosion and reduced soil fertility. Farmers were shown how to intercrop with perennials (e.g., tea, herbs) and fruit trees (e.g., orange, pomegranate), and use green manure crops (e.g., Tephrosia, Crotalaria) to cover the soil while tea bushes and fruit trees grew. In addition to better soil health, these practices generated additional income within two years.
- **GAP certification.** Due to declining soil fertility, many vegetable farmers apply excessive amounts of fertilizer and pesticides to maintain yields. At the same time, local and international consumers are becoming more aware and willing to pay a premium for sustainable and safe produce that is certified. In a private sector collaboration, farmers can obtain certification when using Good Agricultural Practices (GAP). Techniques include improved soil management, reduced fertilizer application, and water conservation techniques, such as drip irrigation and fertigation (fertilizer supplied in irrigation water). In some cases, fertilizer use was reduced by 80% and water use by 60%, while yields increased by up to 20% and labor costs fell by 60%.[508 509]

Ukraine: Farmer Field Schools for Conservation Agriculture

More than 300 farmers in Ukraine are receiving training on conservation and climate-smart agricultural practices as part of the project Integrated Natural Resources Management in Degraded Landscapes in the Forest-Steppe and Steppe Zones of Ukraine.[510] The project's farmer field schools employ a bottom-up approach that includes people-centered learning and direct collaboration between agronomists and farmers.[511 512] Shifting to sustainable agriculture requires a fundamental change in production system thinking to enable adaptation and innovation by farmers, whether as individuals or groups. Local farmers are given hands-on training on low tillage, crop rotation in organic farming systems, and nutrient and plant protection systems. The schools are quite effective in empowering rural people as agents of change.[513]

Africa: Fertilizer Microdosing

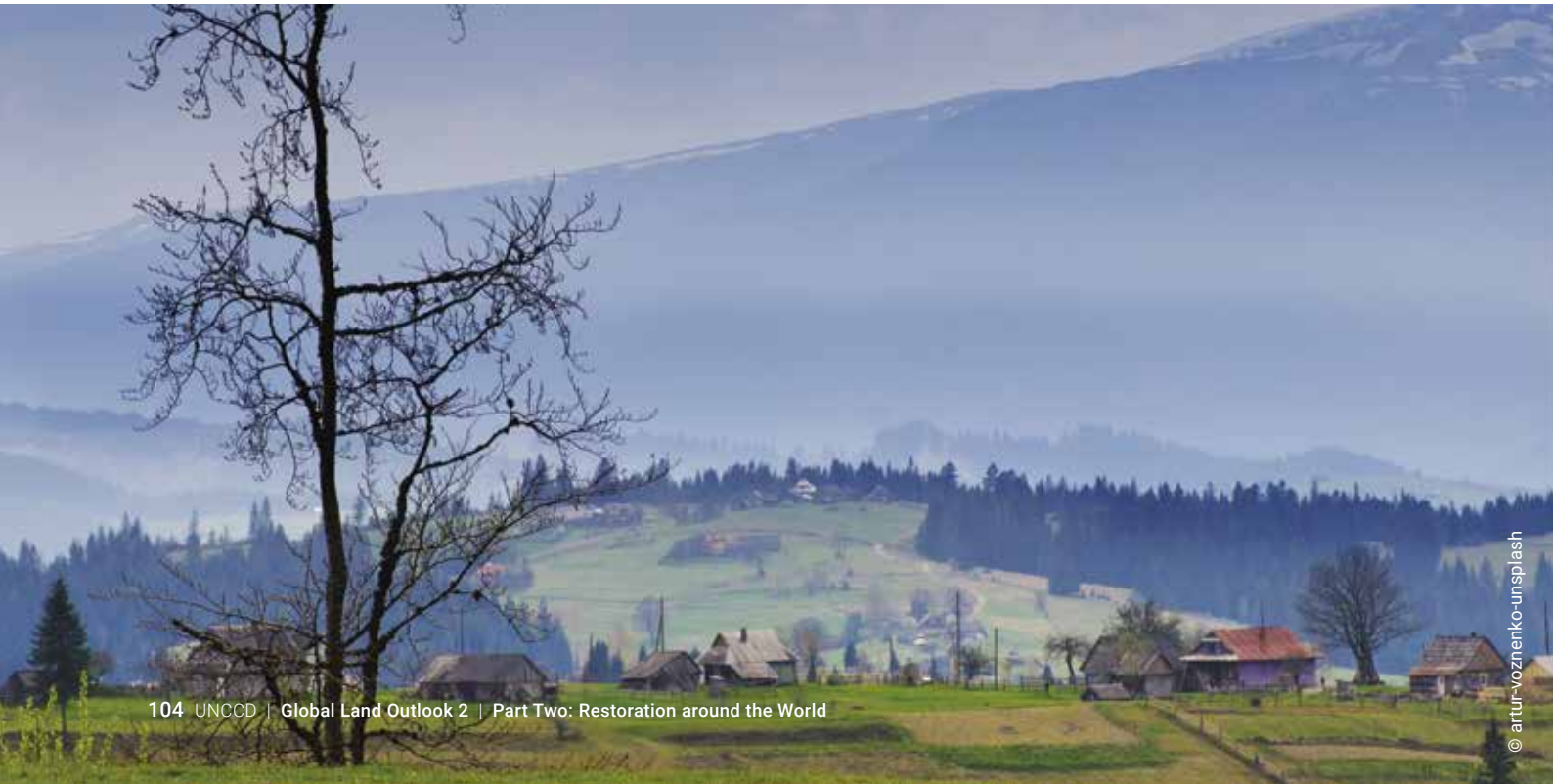
Inadequate nutrient supply and insufficient rainfall are the most important limiting factors for crop production in the Sahelian agroecological zones.[514] Microdosing applications can increase fertilizer use efficiency, reduce upfront investment for poor small-scale farmers, and increase crop growth and productivity. Small doses of fertilizer – a 'three-finger pinch' – at sowing or after planting can increase root growth and help unlock soil nutrients, making plants more resistant to water stress and climate variability. When timed well, microdosing can increase yields by up to 120%. The technique can also be combined with the use of organic manure or other agricultural innovations, such as inventory credit schemes, to enhance sustainability. In Niger, these combinations have been shown to increase household incomes by one-third.[515]

India: Zero Budget Natural Farming

Zero budget natural farming (ZBNF) is an agricultural system gaining popularity across India.[516] It combines traditional and emerging practices to dramatically reduce farmers' direct costs (i.e., zero budget) while boosting yields and overall farm health by using organic inputs sourced locally (i.e., natural farming). Like agroecology, ZBNF takes a holistic approach that considers human, social, and environmental benefits and costs – which have been systematically undervalued – including community cohesion and smallholder livelihoods.[517] The state of Andhra Pradesh aims to roll out ZBNF to its six million farmers through state-funded training and extension services. ZBNF ends a destructive reliance on purchased inputs and loans, providing a solution to extreme indebtedness and suicides among Indian farmers. Its success is due in part to its social movement dynamic – motivating farmers through discourse, resource sharing, local leadership, and a spirit of volunteerism.[518]

Latin America and the Caribbean: Agroecological Transformation

Like ZBNF, agroecology espouses a transformation of conventional agri-food systems. It is driven by social movements that have successfully formed coalitions to promote its integration into public policy across Latin America and the Caribbean. These policies include instruments often embedded in sectoral programs (e.g., family farming, indigenous peoples, biodiversity, climate change) that also support organic and sustainable agriculture practices. There is a growing recognition that agroecology is a viable and profitable alternative to existing agricultural paradigms across the region.[519]



© artur-voznenko-unsplash

Globally Important Agricultural Heritage Systems

Globally Important Agricultural Heritage Systems (GIAHS) are outstanding landscapes that combine beauty with agricultural biodiversity, resilient ecosystems, and cultural heritage.[520] These landscapes and associated food production systems have evolved over centuries and continue to adapt in a rapidly changing world. They provide multiple goods and services in a sustainable manner, as well as food and livelihoods to millions of small-scale farmers. They offer a template for contemporary and future agricultural innovations and technologies that leverage cultural, ecological, and agricultural diversity. However, many are also threatened by climate change, forced migration, or increased competition for land resources. For some of these landscapes, these pressures have resulted in traditional farming practices being abandoned or endemic species being lost.

- **Andean Agriculture, Peru:** Knowledge and methods used in Peru's mountains have been passed on for over 5,000 years. Indigenous peoples have established and maintained terraces, local irrigation systems, and unique cultivation practices used at different altitudes. For example, the waru waru practice consists of water canals that trap solar radiation during the day, releasing warmth at night to stop crops from freezing.
- **Steep Slope Agriculture, Japan:** In a rugged mountainous area deemed unsuitable for cultivation, farmers in Shikoku have built stone walled terraces, and utilize a mulching practice called kaya to reduce soil erosion and keep the slopes intact. Although each farm's cultivation area is small, a large variety of grains and vegetables are grown. Surrounded by forests, these mountain farms are also part of an ecological corridor for wildlife that contributes to biodiversity conservation.
- **Agroforestry System, Morocco:** The agroforestry system in Ait Souab-Ait Mansour is a biodiversity hotspot where Argan trees are grown together with over 50 other plant species that have been cultivated for centuries. This system taps into large underground caverns that catch and filter water from the land above. These natural cisterns are so effective in collecting water that local farmers can thrive despite the arid environment and poor soils.
- **Ancient Olive Trees, Spain:** In Taula del Senia, there are over 5,000 ancient olive trees, many of which are between 1,000 and 2,000 years old. Local communities rely on trees for their livelihoods. Economic activities, such as olive oil production and agri-tourism, rely on cultivation and production techniques handed down through generations from Roman and Arab times.

Restoring Abandoned Agricultural Lands

Degraded farmlands have been abandoned worldwide, currently estimated at between 3.9 and 4.7 million square kilometers, or roughly 30% of the global cropland area.[521] Abandonment is typically due to poor land management or insecure tenure, often in tandem with the depletion of local soil or water resources. Wider socio-economic trends, such as migration and market factors, can also contribute to agricultural land abandonment. No regret response options for bringing these lands back to productive life can be found along the restoration continuum: from rehabilitation for sustainable food and commodity production to ecological restoration or rewilding for biodiversity and climate benefits, including the potential for integration with renewable energy infrastructure.[522]

Back to Nature

Forest and grassland restoration on abandoned agricultural land presents a major conservation opportunity, especially when balanced with the needs of indigenous peoples and local communities.[523] As with other ecosystems, these efforts can be facilitated by both government and non-government actors independently, or in public-private partnerships. There are numerous examples of land trusts and conservation purchases that have already acquired millions of square kilometers of private lands to restore nature around the world.[524]

World Land Trust

The World Land Trust, based in the UK, was one of the first organizations to focus specifically on the conservation of threatened habitats by using land purchases. Across the world, the trust is gifted, buys, or leases threatened land to create nature reserves that are owned and managed by local communities or organizations. In total, the trust has established 9,500 square kilometers of protected areas, from Argentina to Zambia. Once the land is secured and reserves created, funding is directed to implement restoration techniques, such as assisted natural regeneration, reconnecting fragmented habitats, and re-establishing wildlife corridors. The Trust's Keepers of the Wild program offers funds to employ local people to protect and manage the reserves as well as conduct education, training, and environmental awareness campaigns in local communities.[525]

Hungary

After the collapse of the Soviet Union in the early 1990s, there was a large-scale abandonment of agricultural land in central and eastern Europe, driven by low soil fertility and a lack of investment under the former regimes. In Hungary's Great Plain, 760 hectares of grasslands were restored from former alfalfa croplands as part of Europe's largest grassland restoration projects at the time (2009-2010). An evaluation found that both passive regeneration and active restoration (e.g., seed sowing) can be cost-neutral and even profitable within a relatively short period. Seed sowing suppresses weeds and increases biomass production, but at the expense of lower biodiversity compared to spontaneous recovery. In addition to expanding buffer zones for existing grasslands and wildlife habitat, this project enhanced the delivery of critical ecosystem services, such as water purification, soil protection, pollination, and recreation.[526]

Namibia

Community-based Natural Resource Management techniques are being used around the world to create an environment in which people in rural communal areas can actively manage their ecosystems. In Namibia, conservancies are democratically governed by communities through legal constitutions and elected representatives, use annual distribution plans to share income, and plan community development initiatives like infrastructure, schools, water points, and health facilities. A three-pronged approach across communal conservancies has focused on good governance, national monitoring, and income diversification. Improving governance in areas such as decision-making, sound financial management, and proper implementation of conservancy constitutions has helped reduce human-wildlife conflicts and poaching as well as adaptation and mitigation to climate change. A four-year project (2017-2020) targeted 230,000 residents in conservancies and community forests in the Kavango, Kunene, and North-Central regions. Joint ventures with ecotourism operators have become important sources of income for many conservancies.[527] The project also improved income from the marketing of indigenous products, especially Devils Claws and Namibian Myrrh.[528]

People's Republic of China

Starting in 2000, the area of cultivated land in the Loess plateau of China began to drop significantly, primarily due to government projects and programs to reduce human pressures on natural ecosystems. Subsequently, vegetation restoration played an important role in improving ecosystem services, by controlling soil erosion and increasing carbon sequestration. It was estimated that for the restoration of abandoned farmland to a fully stable grassland with historically equivalent biodiversity and a vibrant soil system, around a decade of regrowth was required post-intervention.[529]

Food, Energy, and Restoration

The development of solar and wind farms and other forms of renewable energy infrastructure around the world will continue to accelerate. A truly sustainable green energy transition must therefore be carefully planned and managed so that it does not come at an unacceptable cost to nature. Designing them at the appropriate scale and in an environmentally friendly manner can boost sustainable food production and further land restoration efforts. Solar power plants are projected to cover over 2.5 million hectares globally by 2030, with the industry largely responsible for the stewardship of this land.[530]

Unites States of America

The Silicon Ranch Corporation is a solar power utility company controlled by multinational fossil fuel company Shell, its largest shareholder. Silicon Ranch has created a third-party certified product that combines clean electricity generation with carbon sequestration, ecosystem restoration, and rural economic revitalization. The corporation partners with regenerative livestock producers and local farmers to deploy holistic land use practices like rotational grazing and grassland restoration on its solar farms.[531] In 2020, a partnership between White Oak Pastures and Silicon Ranch commenced regenerative grazing and land management practices on some 950 solar farm hectares in southwest Georgia in the USA. The goal is to enhance carbon sinks, restore biodiversity and soil health, and augment the environmental, social, and economic benefits of solar energy projects. The project's forecasted ten-fold increase in soil organic matter from 0.5% to over 5% is equivalent to the annual removal of approximately 830 tonnes of carbon dioxide from the atmosphere. White Oak Pastures is a major organic meat supplier to Whole Foods (the US organic supermarket chain), illustrating how consumers can play an important role in supporting a sustainable food-energy-restoration production model that creates rural jobs and rehabilitates native grasslands.[532]

People's Republic of China

Astronergy/Chint Solar is a specialized subsidiary of the Chinese-owned CHINT group, developing photovoltaic power stations globally. One project in China, in Jiangshan (Zhejiang province), has transformed abandoned agricultural land into a solar park where a large variety of crops are grown between and under solar panels. Since its inception in 2015, 12 multifunctional zones have been established to organically grow herbal medicines and cash crops and raise poultry by making use of the shade given by the panels. Over 25 years, the total power generation is expected to be 4.9 billion kilowatts, meeting the electricity demands of 400,000 people in Jiangshan while reducing carbon emissions by around 4.5 million tonnes.[533] In addition to the direct economic benefits, the regeneration of formerly abandoned land improves both above and below ground carbon storage, contributing to enhanced biodiversity and ecosystem services, including ecotourism. The Gonghe Solar Park (Qinghai province) covers an area of 298 square kilometers, about five times the size of Manhattan. Over 40 Chinese solar companies have come together to build a solar park with a massive installed capacity of 3,450 megawatts. Associated land restoration efforts promote the recovery of native vegetation and sand-fixing crops through the shading, heat preservation, and moisturizing effect of the panels. Using rotational grazing, around 1,500 Tibetan sheep are also being raised in the park.[534]

Cambodia

Cambodian small-scale rice farmers, already struggling with changes to well-established climate patterns, can no longer rely on traditionally used planting times for rice or other crops. The Scaling-up of Renewable Energy Technologies (S-RET) project started in 2017 and targeted smallholders in 980 villages across five provinces, focusing on women and poor households in remote areas, lacking access to modern, affordable, or reliable energy sources.[535] The project offered private sector renewable energy companies grants (up to USD 80,000) to test RET on actual smallholder farm plots, and subsequent roll-out grants (up to USD 160,000) to establish supply chains and service networks. Twelve agreements provided a range of affordable RET options for smallholders: solar dryers for processing food, portable solar water irrigation pumps, solar poultry incubator to heat eggs, solar cricket incubators, solar hydroponics to growing vegetables with less water, or solar animal feed processing machines. In total, the project supported the use of RETs by over 5,000 small-scale farmers (one-third female) for production, processing, and post-harvest activities. The project also supported Cambodia's National Biodigester Programme, which has installed over 2,600 biodigesters, reducing landfill waste, driving a circular economy, and averting emissions equivalent to 125,000 tonnes of carbon.[536]

Namibia

Bush encroachment affects between up to 450,000 square kilometers in Namibia, some 30% of the country, and is a leading cause of land degradation.[537] [538] In response, a Rangeland Management Policy and Strategy was developed as a public-private partnership to guide the restoration of degraded rangelands by targeted bush thinning.[539] Accumulated biomass 'waste' from thinning is a viable economic activity with one assessment suggesting that bush control and biomass utilization could generate net benefits of around USD 3 billion over 25 years, and support 10,000 jobs annually.[540] To capitalize on this opportunity, the Biomass Utilization by Sustainable Harvest project was launched in 2019 to offer advisory services for harvesting and processing and sustainable supply schemes for bush biomass.[541] Biomass is processed into animal fodder, charcoal, biochar, building material, or wood chips, while the area managed under the voluntary Forest Stewardship Council (FSC) certification scheme has increased from 2,000 to 16,000 square kilometers, improving working conditions and incomes.[542]

2.3.5 SUSTAINABLE PASTORALISM

Pastoralism – extensive livestock production in rangelands – can be an efficient way of utilizing highly variable land resources. It often entails the movement of people and livestock (transhumance) along traditional migration routes that traverse different climatic zones, primarily driven by the availability of water and pasture. This kind of mobility underpins pastoralists' management of risk and uncertainty in drylands. Rangelands are often neglected in the land restoration agenda despite being a major store of carbon with great potential for achieving environmental and development goals.[543]

Pastoralism is not only a strong basis for ensuring stable and secure livelihoods. It is also linked to the cultural and social identity of between 200 and 400 million people worldwide.[544] Food production from pastoralism is an important source of protein (meat and dairy) and animal by-products for subsistence or sale. It can have a relatively low carbon and environmental footprint as it does not rely on fossil fuels, agrochemicals, or imported feed. Historically, pastoralists have maintained good relations with sedentary farming communities: pastoralists rely on farmers for grain and as customers for their produce, while their livestock fertilize farmers' fields and help to suppress weeds. Nonetheless, conflicts arise between farmers and pastoralists, among pastoralist groups, and with the government, sometimes triggered by events like drought, land grabs, displacement, or forced migration.

Kenya: Group Ranches

In Kenya, the Group Representatives Act of 1968 gave Maasai communities group title to land where they tend their herds.[545] These communally owned 'group ranches' provided the pastoralists with security of tenure and control of associated land-based resources.[546] The need for wider mobility builds linkages with outside communities and adjacent group ranches. For example, the Shompole and Olkiramatian ranches, south of Nairobi, agreed to demarcate seasonal grazing areas, set aside some pastures for recovery, and designate others for emergency use. From 2012, they also established a conservation area in which both wildlife and ecotourism thrive, providing attractive opportunities for youth employment.[547]

Tunisia: Collective Land Management Councils

In Tunisia, multi-level governance structures include collaboration between formal Collective Land Management Councils and community-based organizations (Agricultural Development Groups – essentially, farmers' associations). The councils manage access to and local administration of land, while the Agricultural Development Groups administer day-to-day investments and management activities connected with rangelands and natural resource use. Public agencies provide financial, technical, and administrative support when these organizations decide which pastures should be set aside. The Tunisian Union of Agriculture and Fishing also helps resolve disputes between the various communities. After 15 years of collaboration between these organizations, rangeland conditions have improved, and the risks of desertification and land degradation have declined.[548] Additional benefits have included increased biodiversity values in the managed rangelands, and more extensive youth participation in the management processes of community land.

Kyrgyzstan: Pasture Users' Unions

In Kyrgyzstan, the 2009 Pasture Law devolved pasture management to local governments. Herders have been organized into over 750 pasture users' unions that have demarcated zones in which members of each union may graze animals. Unions developed grazing plans for each area, and invested in local infrastructure, such as roads, bridges, and watering points. These upgrades have helped lower stocking rates while improving productivity, with higher meat and milk yields. The boundaries have proven to be effective, with herders still able to practice traditional transhumance – moving their flocks up to mountain pastures for the summer and down to the valley for the winter.[549]

Scandinavia: Reindeer Herders

In Scandinavia, Sami reindeer herders are represented by Sami parliaments in **Finland**, **Norway**, and **Sweden** as well as by a series of community organizations that advocate for their interests and negotiate with governments, individuals, and businesses. The Sami Council is a non-governmental association that brings together different Sami member organizations

across Finland, Norway, Sweden, and Russia. It is also a permanent member of the Arctic Council, an intergovernmental organization that includes eight national governments in the Arctic region. The International Centre for Reindeer Husbandry and the Association of World Reindeer Herders, both based in Norway, provide further support. These arrangements give the Sami a voice in protecting their reindeer rangelands from encroachment by commercial forestry, renewable energy and infrastructure development, or mineral and fossil fuel exploitation.[550]

Peru: Alpaca Herders

Across the Andes, collective forms of land tenure have been an essential component of pastoralist life throughout history. In the Arequipa province of southern Peru, herders raise alpaca across the Altiplano as their primary income source. Traditionally, they managed pastureland communally, where individuals held rights to graze their herds for a specific period in designated areas. However, in the last 20 years, several factors have begun to disrupt this formerly stable arrangement. The rising value of alpaca fiber and improved tenure security have increased animal stocks, leading individual families to exert exclusive control over formerly communal land. At the same time, increased climatic variability is reducing pasture quality. Changes to inheritance rules are causing further fragmentation of land parcels, and improved roads have connected pastoralists to markets and increased the demand for manufactured goods using alpaca fibers. In addition, the youth are abandoning their herding roots as they gain ready access to education and higher incomes in urban areas.[551]

Europe: Urban Pastoralism

Across Europe, livestock is making a comeback in many cities. Long banished to the countryside, sheep and goats can be once again seen in parks and other open spaces in the continent's urban areas. They keep grass short, check the growth of weeds, and trim shrubs and hedges, so municipalities can save on mowing, horticultural, and other upkeep costs. City governments from Spain to Romania now contract shepherds to graze open communal areas.[552] [553] Shepherds use temporary fencing, arrange water supply, and move their flocks regularly.[554] [555] Some offer educational activities for children, school groups, and the public. In Turin, livestock graze and maintain two large parks;[556] [557] in Barcelona's Collserola Park, sheep trim undergrowth, reducing fire hazards;[558] and in Cologne, sheep graze and strengthen the integrity of dikes that protect the city from flooding.[559]

2.3.6 URBAN RESTORATION

Urban Source Watersheds

Globally, there are 29 megacities with populations exceeding 10 million people. Almost all are dependent on surface water for their supply of clean freshwater, ultimately reliant on the precipitation that falls in their watersheds (precipitationsheds). Land use and management practices in these source areas impact the downstream quality and supply of water to urban areas.[560] Watershed or catchment degradation is widespread, with 90% of cities losing significant amounts of their surrounding natural land cover to agriculture and development.[561] As a result, water treatment costs due to sediment or nutrient pollution have increased by 50% for one-third of large cities globally.[562]

The number of large cities exposed to water scarcity is projected to increase from around 200 to nearly 300 (including between 10 and 20 megacities) by 2050.[563] While wealthy cities can import water or build desalinization plants, many developing countries have few such options and must rely on hinterland water resources.[564 565] Some cost-effective solutions to ameliorate expected water scarcity are available, including conserving and restoring forests and grasslands in source watersheds to avoid further degradation.[566] Integrated water resources management is a proven strategy that engages multiple stakeholders throughout an entire watershed.[567] This can be implemented in parallel with government policies, such as zoning or other land use regulations, or by payment for ecosystem services schemes. Regardless of the mechanisms or incentives, urgent work is needed to protect source watersheds to future proof urban water supplies.

Nairobi, Kenya

In Kenya, the Tana River supplies 95% of the water consumed by Nairobi's four million residents and another five million people living in the watershed. It also supplies important agricultural areas and provides half of the country's hydropower output. The Upper Tana-Nairobi Water Fund is a public-private partnership established to address the impacts of climate change and unsustainable farming practices. The fund's goal is to protect and restore the quality and supply of water to this economically vital region and is based on projections that a USD 10 million investment should return USD 21.5 million in economic benefits over a 30-year period. The fund expects to work with 50,000 farmers by 2022, providing them with skills, training, and resources to reduce soil erosion, conserve water, and improve agricultural productivity. It targets the most at-risk areas of the watershed, helping farmers take practical steps to increase food and water security, using techniques such as vegetated riparian zones, terracing, agroforestry, reforestation, and water harvesting.[568 569 570]

São Paulo, Brazil

Approximately 46% of the water consumed by the São Paulo metropolitan area in Brazil (home to 20 million people) comes from the Cantareira supply system.[571] The system includes five interconnected reservoirs in the city's hinterlands, which are part of the headwaters of the Piracicaba watershed. These catchments have lost as much as 70% of their original forest due to agricultural and urban expansion. Prompted by droughts and increased water scarcity, local stakeholders began to undertake conservation and restoration measures as part of a central water management strategy to safeguard the Cantareira system. In 2005, a pilot program paid farmers and ranchers USD 120 per hectare to reforest or terrace their fields to improve water quality. The federal watershed committee collects fees from water users that are then disbursed to farmers and ranchers who protect or restore riparian forests on their lands. Program success was based on the development of local watershed committees to unite stakeholders and establish support for payment schemes; building of institutional capacity and political will; and adaptation of policies and legislation to underpin strategic aims.[572 573 574]

Beijing, China

The Miyun Reservoir watershed, located between Hebei Province and Beijing Municipality, supplies drinking water to over 20 million residents of Beijing, the capital of the People's Republic of China. It is also a major store of water from the massive South-to-North Water Diversion Project. To safeguard water quality in the reservoir, a suite of nature-based solutions was applied upstream, including forest landscape restoration coupled with biodiversity conservation, agroforestry, riparian buffer zones, sewage management, green infrastructure, and environmental education for residents. By using natural infrastructure to pre-empt a looming water crisis, the project demonstrated that with the help of local communities, ecological rehabilitation and protection of watersheds can ensure sustainable water supplies to the capital.[575 576 577 578]

Cape Town, South Africa

In South Africa, the Greater Cape Town Water Fund was established in 2016 in response to serious water insecurity in the greater Cape Town region. The fund brings together private and public sectors stakeholders to restore the catchments supplying the city's water. In 2018, the fund published a business case for ecological infrastructure investment, which estimated the value of landscape level interventions necessary to secure and protect critical water catchment areas. It concluded that investing USD 25 million would generate annual water gains of 100 billion liters within 30 years, half of which would become available in five years when compared to a business-as-usual scenario. It also concluded that catchment restoration is higher yielding and more cost-effective, supplying water at 10% of the unit cost of alternative options.[579 580 581]

San Jose, Costa Rica

Agua Tica is a fund helping to protect water sources in the Rio Grande and Virilla river basins which supply water to San Jose, the capital of Costa Rica. The fund identifies conservation needs through scientific assessments, creates public-private partnerships to provide technical expertise and funding, and then invests resources in conservation activities in the middle and upper catchments to ensure long-term water security. Nearly two million people in the capital metropolitan area benefit from the activities, with an estimated 600,000 cubic meters of water recharged annually and over 600 hectares of forest that are now protected and undergoing rehabilitation.[582 583 584]

Manila, the Philippines

The water supply for 15 million people who live in and around metropolitan Manila depends almost exclusively on three watersheds (i.e., Angat, Ipo, and La Mesa) in Quezon and Bulacan provinces. These watersheds provide over four million liters of water per day, just enough to meet current demand. Significant water shortages are expected soon, and both the public and private sectors are looking for solutions. While the Angat is largely intact, only 40% of the Ipo watershed retains its natural forest cover. Reforestation is seen as an important intervention for safeguarding Manila's water supply and is central to the national watershed protection strategy. For the Ipo, this includes an Adopt-a-Watershed program, a multi-stakeholder partnership that supports volunteers to plant trees and restore denuded hillsides. Another program involves granting a Certificate of Ancestral Domain Title for the indigenous Dumagat tribes, who manage about 16% of the watershed. As a result of these efforts, forest cover in the Ipo watershed has nearly doubled in just three years, from 43% in 2017 to 81% in 2020.[585 586 587 588]

New York City, USA

In the USA, the Catskill watershed in upstate New York is a prominent example of working with nature to reduce costs and deliver critical water services to New York City. Historically, this watershed provided residents with high-quality drinking water. In the late 1990s, in the face of growing development pressures in the largely privately-owned Catskill and Delaware watersheds, New York City initiated a plan to protect its source water and avert the costly alternative of a USD 10 billion filtration plant. Strategic investments in the 5,000 square kilometer watershed cost approximately USD 1.5 billion, with an annual USD 100 million injection into the rural economy through its upper reaches. The program incentivized land management changes and innovative fiscal tools, such as purchasing land around reservoirs to preserve forests and wetlands that provide a buffer against pollution, paying landowners to restore forest along streams, and offering technical assistance and infrastructure support to farmers and forest managers.[589 590 591 592]

Urban Food Production

Urban farms are important for food security and as proactive response to supply chain interruptions. An estimated 40% of urban households in sub-Saharan Africa partly depend on urban and peri-urban agriculture for food, and this proportion will rise as urbanization increases.[593] Urban food production is found in back gardens and on roofs, in open public spaces, and micro agricultural systems (i.e., indoors, outdoors, or vertical). It includes organic farms, permaculture, community gardens, fishponds, livestock rearing, beekeeping, and orchards. Shorter supply chains reduce emissions and transport costs, and curb post-harvest food losses resulting from inadequate preservation and distribution. Urban food production can also create green spaces that contribute to flood control and temperature regulation while enhancing urban biodiversity and ecosystem services.

Urban food production creates meaningful work, generates income, particularly for women and youth, and enhances local food security by reducing dependence on regional and global food markets.[594] Despite their importance for urban greening and quality of life amenities, crop and livestock production is illegal in many cities. These activities are often tacitly ignored by authorities and are rarely considered by formal land use planning processes, which poses major challenges for urban farmers.[595] In many developed countries, the growth of urban agriculture and value-added food processing is linked to a return to localism, and a rise in social entrepreneurship, environmental sustainability, and the desire for green urban infrastructure.[596]

Africa

Across Africa, regional hubs like Nairobi in Kenya, Kampala in Uganda, and Dar es Salaam in Tanzania have developed urban agricultural policies thanks to the combined efforts of civil society groups and municipal politicians.[597] During the COVID-19 lockdown and its associated transport restrictions, urban and peri-urban farmers began supplying city food markets throughout the world.[598] In Dar es Salaam, urban agriculture comprises at least 60% of the informal economic sector and is the second largest urban employer. In Lusaka, Zambia, over half of the residents tend home-based gardens primarily for their own consumption.[599] In Yaoundé, Cameroon, many urban households raise livestock, including poultry, dairy cattle, and pigs, producing more than 20,000 tonnes of manure per year and reducing the need for costly fertilizers.[600]

Latin America

In Latin America, innovative urban agriculture models could be replicated in many cities. Mexico City meets about 20% of its food demand via rooftop and vertical gardens. A thriving urban agriculture movement has developed among residents seeking a healthier and more sustainable lifestyle. The Huerto Tlatelolco urban garden includes an edible forest with 45 tree varieties, a seed bank, and a large bio-intensive vegetable garden.[601] In addition to local food security and community engagement, these operations show great potential for capturing stormwater runoff, reducing air pollution and temperatures, and efficient water treatment and reuse during dry periods.[602]

Europe

In Europe, urban agriculture is recognized in the European Union biodiversity strategy as an important tool for urban and peri-urban greening and to retain urban biodiversity.[603] Often these operations are located near supermarkets, restaurants, and distribution centers, so that vegetables are grown and harvested close to the point of purchase or consumption. The Berlin-based startup InFarm is a rapidly growing urban farming network with over 100 city farms in 10 countries.[604]

© diamond geezer


© risingthermals_flickr

Daylighting Urban Waterways

Rivers and streams have been buried underground as cities and urban areas have developed over time. These watercourses receive no sunlight and are devoid of most biodiversity. In the past, these urban waterways were open air conduits for connecting social and economic activities as well as supporting ecological integrity and flows.[605] The global movement to daylight rivers and streams in cities worldwide aims to uncover waterways buried in culverts or pipes and restore their natural and economic services and functions.

Climate change has been a major driving force behind large-scale investment in urban daylighting projects. Daylighting requires engineering investments to remediate contaminated soil and water and restore channels and banks to semi-natural conditions. The passive cooling provided by open water courses can help reduce the intensity of urban heat island effects. Creating new habitat for plants and animals potentially reduces flood risks and can generate new amenities, such as recreation, attractive business districts, and green corridors. While this may appeal to developers, as waterside property values rise, and to water companies for lower maintenance costs, there is also the possibility to include the needs and interests of marginalized urban residents in the decision-making process.[606]

- In Seoul, **Republic of Korea**, the Cheonggye Stream Reconstruction Project is a high-profile example, inspiring similar projects around the world. It removed the concrete road surface that had covered the stream course for decades, reconstructed a channel, restored the surface flow by pumping water from the river's downstream area, and reintroduced riparian vegetation. The project's many benefits include a significant increase in urban biodiversity values, a reduction in urban heat island effect and air pollution, an improvement in residents' quality of life, and greater economic development in the surrounding area.[607]
- In Auckland, **New Zealand**, underground piping and clay were removed to daylight the Fairburn and Parahiku reserve streams in 2014. The restoration works provided better flood water protection and helped reverse declining populations of migratory fish species.[608]
- In Riyadh, **Saudi Arabia**, the Wadi Hanifa Restoration Project was completed in 2009. It restored the natural ephemeral drainage pathways for rainwater, floods, and surface water flowing from different parts of the city. Extensive tree planting and revegetation created an attractive public area for residents with walkways, recreational activities, and parks.[609]
- In Zurich, **Switzerland**, urban river restoration has been common practice for over 30 years. Urban rivers have been daylighted and integrated into Zurich's water and sewage planning activities, with funding generated by the reduction in water treatment costs.[610]
- In the **UK**, Rochdale successfully restored the river Roch in 2015 by daylighting it through the town center. In England's former industrial north, uncovering Porter Brook has been the first step in a new project to restore Sheffield's lost urban rivers. In southeast London, the restoration of the Quaggy River through Sutcliffe Park provides a flood storage wetland area, wildlife habitat, and amenity space that has increased land values in the area.[611]
- In the **USA**, the Strawberry Creek Restoration Program in Berkeley, California, is considered an archetype for stream daylighting projects around the world.[612] More recently, USD 34 million was allocated to daylighting the Saw Mill River in Yonkers, New York, to create a public park and restore riparian habitat for migratory fish.[613]

Revitalizing Urban Landfills

The world generates two billion tonnes of municipal solid waste annually, much of which is not managed in an environmentally safe manner. Globally, 37% of all waste ends up in some type of landfill: open dumping accounts for about 33%, around 8% is disposed of in sanitary landfills with gas collection systems, 19% is recycled or composted, and 11% is incinerated. Adequate waste disposal and treatment, such as controlled landfill or recycling facilities, is almost exclusively the domain of developed countries. Low-income developing countries generally rely on unregulated open dumping, often accounting for more than 90% of all disposals. By contrast, developed countries dispose of little more than 50% of their waste in landfills.[614]

Landfills, especially open dumps, pose serious environmental and public health hazards, mainly from toxic gases emitted from decaying waste. Leaching also causes substantial pollution of soils and groundwater.[615] When designed and monitored properly, closed or landscaped landfills can provide valuable space for recreation or even industrial uses, such as recycling or composting activities. Examples of landfill transformation can be found in many cities around the world.

New York, USA: The World's Largest Landfill

Fresh Kills – where in the late 1970s an estimated 25,000 tonnes of trash arrived everyday – has been transformed into an oasis of grasslands and marshes in New York City. While innovations in ecological engineering, methane capture (which provides residents with energy supplies), and some revegetation jumpstarted the process of restoration, the natural regeneration of flora and fauna remains the primary driver of recovery. Opened to the public in early 2021, this urban park, while a stark reminder of how much waste has been generated, is already seen as a symbol of urban renewal, rebirth, and rejuvenation.[616 617]

Hiriya, Israel: Creating an Urban Green Lung

The largest landfill dump in Israel has undergone a massive makeover that has seen a former mountain of waste turned into an 800-hectare ecological park – three times the size of New York City's Central Park. By 2007, this new 'green lung' featured a 60-hectare recycling station, walking and cycling trails, a 50,000-seat amphitheater, picnic grounds, and a water and sports park. The biogas generated from this former landfill, once a toxic pollutant, is now being reused.[618 619]

Wuhan, China: A Green Haven Rises

The city of Wuhan has transformed the Jinkou Landfill – one of its most polluted areas containing an estimated five million cubic meters of waste – into an ecological haven for its residents. Using aerobic ecological restoration techniques to alleviate the risk of long-term safety issues (e.g., pollution, methane explosions), the project has restored over 50 hectares of land, resulting in increased land values and economic development in surrounding areas. The recreational park, dyke, and urban forest has improved the quality of life for 14 adjacent communities that are home to some 400,000 people.[620 621 622]

Garraf, Spain: Landscape Restoration of the Vall d'en Joan

Some 85 hectares in a winding valley in the foothills of the Garraf massif were used as a landfill site by the Barcelona metropolitan area. The valley was filled with waste to a height of 70 meters over more than 30 years until 1974 when the closure of the site began. Landscape restoration used a mosaic of farms and woodlands to regenerate the site's primary ecosystems. Terraces helped reduce erosion and collect water for irrigation while harnessing the biogas now supplies electricity for over 10,000 people annually. Public access has been opened with an information center explaining the restoration work.[623 624 625]

Puchong, Malaysia: The Worldwide Landfill Park, Air Hitam

The Air Hitam landfill in Puchong opened its doors to waste in 1995 and was one of the main landfills serving several major local councils in the Kuala Lumpur metropolitan area. Beginning in 2011, the 40-hectare landfill was turned into a community park called the Worldwide Landfill Park. It includes a five-kilometer jogging path, a bicycle track, and a children's playground. Noticeable among the lush greenery are 164 gas wells that supply electricity to 2,000 adjacent homes.[626]

2.3.7 GREAT GREEN WALL FOR THE SAHARA AND THE SAHEL

The Great Green Wall (GGW) is a symbol of hope endorsed by the African Union in 2007. It is one of the first large-scale land restoration initiatives and brings together African countries and international partners, under the leadership of the African Union, and coordinated by the Pan-African Agency of the Great Green Wall (PA-GGW). The goal of the GGW is to restore Africa's degraded landscapes and transform millions of lives throughout the Sahel by creating and maintaining a mosaic of restored and productive land stretching 8,000 kilometers across 11 countries, the entire width of the continent.

In recent years, the vision has evolved from a tree-planting program to an integrated ecosystem management approach, striving to optimize a mosaic of different land use systems. The GGW initiative aims, by 2030, to restore one million square kilometers of degraded land, sequester 250 million tonnes of carbon, and create 10 million green jobs.[627] More than 50 sustainable land management and ecosystem restoration projects have been initiated since 2012, involving a broad range of actors at national and regional scales. These projects range from forestry and agriculture (e.g., reforestation, agroforestry, conservation agriculture, and farmer-managed natural regeneration) to water (e.g., watershed management) and soil measures (e.g., terracing and erosion control measures). Nevertheless, the most recent GGW assessment report showcased preliminary results underlining that, depending on geographical scope, only 4–20% of the initial land restoration target was reached by 2020, and that it would be necessary to increase the current pace of land restoration to over 80,000 square kilometers annually.[628]

FIGURE 2.5 Map of the Great Green Wall

Source: PA-GWW

Implementation Challenges

The GGW has numerous implementation challenges – such as land governance, monitoring and reporting, funding, and technical capacity – related to the need for high-level political support, weak organizational structures and processes, and a lack of coordination and mainstreaming across sectors (e.g., agriculture, forestry, mining, rural development) and countries. Aside from the political risk of investing in fragile nations, many GGW projects generate low economic returns compared to the significant environmental and social benefits accrued that often have little or no market value. GGW countries often struggle to establish the land governance and project structures necessary to attract, access, manage, and report on financial flows.

Monitoring and reporting protocols often overburden government institutions and project managers, negatively impacting subsequent funding contingent on performance criteria. There is a great need for strengthened monitoring and evaluation capacity at national and local levels to surmount this issue. Stakeholder involvement and ownership requires project engagement strategies, community training, and more secure tenure. This would help smallholders co-design and implement projects that account for the financially fraught hiatus between planting and revenues. Unclear tenure and resource rights add further complexity to project governance and jeopardize outcomes and benefit sharing – with carbon credits as a case in point.[629]

Great Green Wall Accelerator

To boost and accelerate restoration efforts, the Great Green Wall Accelerator (GGW-A) was launched during the One Planet Summit in January 2021. Its goal is to facilitate coordination and collaboration of donors and GGW stakeholders, and to develop a comprehensive and common results management framework. During the summit, the GGW initiative gained additional impetus with a pledge of USD 16 billion through political and financial support from the World Bank, African Development Bank, European Union, and other partners.[630]

Built on existing institutions, involving all GGW partners (countries, development banks, civil society organizations, regional and international organizations, private sector), and hosted by the UNCCD in partnership with the PA-GGW, the GGW-A structured approach is based on five pillars: investment in small and medium-sized farms and strengthening value chains, local markets, and exports; land restoration and sustainable management of ecosystems; climate resilient infrastructure and access to renewable energy; favorable economic and institutional frameworks for effective governance, sustainability, stability and security; and capacity building.[631]

This broad approach will help identify transformative mechanisms to better support GGW activities to promote conservation, sustainable agriculture and value chains, and ecosystem restoration to deliver food and water security, improve household incomes, and increase carbon storage in soils. It will also support communities living along the GGW by increasing fertile land, delivering meaningful economic opportunities for the world's youngest population, and building climate resilience in the region. By 2020, 350,000 jobs had been created and USD 90 million generated by communities in the GGW intervention zone.[632]

> "The desert is spreading cancer. We must fight it. That is why we have decided to join in this titanic battle."[633]
>
> Abdoulaye Wade, President of Senegal (2000-2012)

Senegal: Gender, Youth, and Pastoralists

In Senegal, the length of the GGW is 545 kilometers, covering over 8,000 square kilometers across 16 municipalities, all populated largely by pastoralists. Activities focus on land restoration and agroforestry to provide food and energy security, create green jobs, and maintain biodiversity.[634] Since 2008, around 18 million trees have been planted on 400 square kilometers of land, with an annual budget of USD 200 million for planting and maintenance.[635] While a focus on trees and forests dominates GGW activities in Senegal, the authorities continue to advocate for a more holistic approach to achieve rural development priorities.

GGW efforts now include support for multi-purpose gardens, along with the provision of water and training, which has reduced the burden on women, strengthened their solidarity and capacities, and offered more financial independence, including through loan schemes. Youth employment in nursery and reforestation activities has increased, as have diversified incomes on pastoral farms that have had to modify grazing and watering practices in response to greening activities.[636] The establishment of horticultural enterprises has boosted seasonal employment and generated incomes through the sale of vegetables. This has led to increases in crop diversity, food availability, and traditional medicines, which have improved human health.[637]

Niger: Farmer-Managed Natural Regeneration

Under both the French colonial regime and post-independence governance in Niger, trees belonged to the government and not the local community.[638] In 1993, the country enacted a Rural Code that recognized private land rights acquired through customary tenure, and a Forest Law in 2004, which finally gave tree tenure to landowners.[639] The law brought hope that decades of deforestation and land degradation could be arrested and reversed. Today, farmer-managed natural regeneration (FMNR) is a central part of the GGW campaign in Niger. The strategy involves selecting and pruning stems regenerating from stumps of previously felled, but still living trees. This method of reforestation on agricultural lands was pioneered by Tony Rinaudo in the early 1980s while working in the Maradi Department in southern Niger.[640]

FMNR is a form of coppicing and pollarding, a silvicultural technique practiced since pre-historic times. In Niger's recent climate and farming culture, trees were widely seen as unwanted competitors to food crops – as problems to be eliminated. Years of severe drought and land degradation, however, have changed attitudes and resulted in a 'Food for Work' program in Maradi, in which 95 villages were encouraged to use FMNR methods. Crops grew better among the trees, and villagers benefited from extra fuelwood for home use and sale. These modifications to traditional agricultural practices led to nearly 50,000 square kilometers of cropland being restored by 2011. The trees provide food, fodder, and fuel while improving soil health. These first 50,000 square kilometers re-greened produced 500,000 tonnes of food each year, enough to feed 2.5 million people – 10% of Niger's population. Easy access to trees now means that women who once spent hours each day gathering firewood can do other things instead.[641] [642]

Key lessons from Niger's experience with FMNR are that:

- tenure security is a vital precursor
- land restoration and food production must be linked
- innovation by local people, using indigenous knowledge, is critical for success
- a single technique or practice alone is rarely enough, but can serve as a trigger for other innovations
- undertaking multiple innovations simultaneously accelerate improvements
- a single menu of technical options can be adopted at large scales, but it must be flexible, adaptable, and testable by farmers under local conditions
- when communities work together, collectively they produce more sustainable benefits
- resource conservation innovations need to provide swift benefits – in the first or second year – to win support
- technical innovations require coordinated, flexible configurations of actors[643]

This FMNR experience from Niger was used to shift the GGW focus from solely large-scale tree planting programs to the incorporation of natural regeneration of indigenous tree species. As a result, the GGW project has become a metaphor for a green landscape mosaic born from a suite of restoration strategies, rather than a literal wall of trees.[644]

Burkina Faso: Strengthening Implementation Capacity

Thomas Sankara, the folk hero former president of Burkina Faso, once marshalled a nation to halt the spread of the Sahara. Decades after his death, the GGW is bringing his vision to reality.[645] Burkina Faso's first GGW action plan covered five administrative regions, and efforts are now focused on achieving LDN targets adopted in 2017. These include the restoration of 60% of degraded land in the priority zone, increasing national forest cover to 20%, reducing by half the proportion of people vulnerable to food and nutritional insecurity, and lowering the incidence of poverty in rural areas to below 35%. A resource mobilization effort in 2018 attracted USD 30 million from eight different donors.

Capacity building to consolidate the governance of GGW activities at national and local levels has advanced significantly. This includes setting up decentralized structures within the Ministry of Environment and strengthening their capacity to: guide, monitor, and evaluate interventions; mobilize resources; train implementing actors; and better communicate to all stakeholders. Two years of restoration work funded by the Action Against Desertification project, part of the GGW initiative, has created 104 proof of concept sites across 60 villages in Burkina Faso. The plots and species used in these sites were chosen in conjunction with local communities and were based on evidence from current plant science research. The potential for land restoration is estimated at over 10,000 square kilometers, which – if successful – would make the country self-sufficient in food.[646]

Nigeria: Restoring Land and Livelihoods

In Nigeria, the national GGW program is being implemented across 11 frontline states, with a population of over 40 million people and comprising 43% of the country's land. Nigeria is threatened by recurrent droughts, persistent land degradation, and encroaching desertification.[648] Forests are disappearing at an alarming rate, with some states losing over half since 2007. Grasslands and wetlands are also being heavily encroached upon.[649] One of the key components of the national GGW program is the establishment of a contiguous 1,400-kilometer shelterbelt (windbreak) from Kebbi state in the northwest to Borno state in the northeast, to ward off Harmattan winds from the Sahara.[650]

The Action Against Desertification project in the north of Bauchi, Jigawa, and Sokoto states aims to upscale restoration activities linked to income generation and capacity building. The intervention has reached over 70,000 people in rural communities with a particular focus on women and youth, as well as farmers, pastoralists, and local authorities. As part of a joint effort, the Ministry of Environment, the National Agency for the Great Green Wall,[651] the Forestry Research Institute, and local authorities, together with the FAO, succeeded in restoring 43 square kilometers of land: 21 tonnes of seeds of woody and herbaceous species were sown, 291,000 tree seedlings were planted, and over a tonne of vegetable seeds were provided for micro-gardens. Training sessions and workshops also supported village enterprises around fodder, beekeeping and honey production, date oil extraction and marketing, as well as the harvesting and commercialization of gum Arabic. So far, the project has benefited over 21,000 people, of which one-quarter were women.[652]

Niger, Nigeria, and Senegal: Household Surveys

While there are limitations, rural household surveys (conducted between 2016 and 2020) point to socio-economic benefits derived from GGW land restoration activities. Respondents' perception of food insecurity and availability improved significantly during the five-year period, as did women's contribution to land management and value chains. Survey evidence shows that the interventions have improved vegetation cover and may have helped to break negative feedback loops that link reduced rainfall due to climate change, the use of natural resources for agriculture and livestock, and the collection of biomass for human use. The most pronounced socio-economic effect of restoration activities was an observed increase in household incomes.[647]

Sudan: Sustainable Land and Water Management

In 2015, a National Action Plan in Sudan was established to implement GGW actions to improve land and water management practices.[653] These included rehabilitating and managing forests, establishing shelter belts, fixing sand dunes, and demarcating animal migration routes and livestock grazing rotations.[654] Village Development Committees, with gender-balanced participation, were created to facilitate training on management practices and other initiatives, including the introduction of more efficient cook stoves and community vegetable gardens. This collective approach has enabled people to have a say in their development agenda, given communities more agency and a sense of ownership, and increased citizen participation in the implementation of GGW activities. By 2020, over 1,100 square kilometers had been brought under sustainable land and water management practices, and over 200 square kilometers of land and forest under enhanced biodiversity protection.[655] The project also includes a capacity-building component, providing training and essential equipment for government institutions involved in the management of forests and protected areas, rangelands, and wildlife.

Mauritania: Lots of Little Wonders

Desertification in Mauritania is compounded by climate change and human activities – 70% of the country's people live in rural areas and are directly dependent on natural resources for their livelihoods.[656] The GGW intervention zone, which covers six provinces home to around half a million people, promotes sustainable landscape management, including capacity building to support sustainable value chains. Over 1,000 hectares of degraded land have been restored using a combination of interventions: fencing to control grazing pressures; vegetation enrichment – gum Arabic seedlings and herbaceous fodder species; and soil and water conservation practices (e.g., stone bunds, zai pits). This integrated approach has increased incomes and livelihood opportunities for an estimated 165,000 people, of which half were women. Full-time jobs were created in nurseries, mills, and shops. Fodder sales have enhanced incomes, and many women now have access to vegetable gardens for at least six months of the year. Finally, the project helped establish and develop the gum Arabic sector in Mauritania through a series of consultative workshops and marketing studies.[657]

Ethiopia: Sustainable Land Management Project

In Ethiopia, the government has pledged to restore 150,000 square kilometers of degraded and deforested land by 2030. Activities under the GGW initiative aim to conserve and restore land while creating income-generating activities to reverse migration flows.[658] The Ethiopian Sustainable Land Management Project (SLMP) has successfully reversed a vicious cycle in which disempowered and unorganized rural communities, resource degradation, erosion and flooding, vulnerability to drought, and deepening poverty have been transformed into a large-scale regeneration of landscapes and livelihoods.[659]

Between 2008 and 2019, the SLMP was implemented in two phases, designed primarily to reduce land degradation and improve agricultural productivity. The first phase introduced SLM practices to rehabilitate degraded areas within 45 critical watersheds, across six states in the highlands. The second phase sought to scale up this support by expanding the coverage to 135 watersheds, integrating new activities targeting land productivity, deforestation, and reduced greenhouse gas emissions.[660] In total, more than 8,600 square kilometers of degraded landscapes in 1,820 micro-watersheds were brought under improved management practices, across both communal and individual landholdings. In addition, close to 1,000 square kilometers were either reforested or afforested,[661] while agroforestry and grazing exclosures increased vegetation cover and moisture retention in targeted watersheds.[662]

One unique feature of the SLMP was the issuance of landholding certificates to over 360,000 households. Nearly a third of those were issued to women, who received certificates either individually or jointly with a man. Moreover, almost 10,000 landless youth (over one-quarter women) were issued certificates or other legal documentation to use communal landholdings in exchange for restoring 2,737 hectares of land.[663] This element of the project is ongoing with the Ethiopian Climate Action through the Landscape Management Program for Results.[664] Overall, the SLMP decentralized implementation structure and a participatory planning approach helped to ensure its success.

Eritrea: Tenure Security for Sustainable Land Management

With over 80% of the rural population engaged in agricultural activities, severe land degradation is arguably the most critical environmental problem facing Eritrea. As part of its GGW intervention zone, a Ministry of Land and Water and Environment project focusing on SLM practices was implemented between 2012 and 2015 in 28 villages within the Serejeka sub-zone, covering over 210 square kilometers of agricultural land. The objective was to create a functional model of soil and water conservation activities, along with a new land tenure system called 'xlmi'. This system allows landholdings to be passed down through generations as family property whereas the prior system used seven-year leases, followed by redistribution among local smallholders.[665]

Farmers, village administrators, and extension workers participated in workshops, meetings and capacity-building activities focused on desertification control measures, SLM practices, and land use classification procedures for the implementation of the new tenure system. Improved farming techniques and afforestation, in combination with more secure tenure, has benefited around 54,000 smallholders, of which 40% were female-headed households. More than two million trees have been planted on 1,200 hectares of land, with a survival rate of over 80%.[666] Wild animals and pollinators have returned to these forested lands,[667] [668] and farmers, primarily women, received apple and avocado trees to plant.[669] The use of modern smokeless stoves has reduced demand for firewood,[670] and non-arable land was allocated to farmers for long-term use for grazing or to plant tree species of their choice, to harvest and sell the produce.[671] The xlmi tenure system has significantly reduced deforestation and land conflicts while providing farmers with secure long-term benefits and increased household income.

ENDNOTES

1 United Nations Convention to Combat Desertification, 1994. Convention Text. https://www.unccd.int/sites/default/files/relevant-links/2017-01/UNCCD_Convention_ENG_0.pdf

2 Carrão, H., Naumann, G. and Barbosa, P., 2016. Mapping global patterns of drought risk: An empirical framework based on sub-national estimates of hazard, exposure and vulnerability. Global Environmental Change, 39, pp.108-124. https://doi.org/10.1016/j.gloenvcha.2016.04.012

3 FAO, 2021. The impact of disasters and crises on agriculture and food security. Rome. https://doi.org/10.4060/cb3673en

4 Otkin, J.A., Svoboda, M., Hunt, E.D.0, Ford, T.W., Anderson, M.C., Hain, C. & Basara, J.B. 2018. Flash droughts: A review and assessment of the challenges imposed by rapid-onset droughts in the United States. Bulletin of the American Meteorological Society, vol. 99, no. 5, pp. 911-919. https://doi.org/10.1175/BAMS-D-17-0149.1

5 Gjerdi, H. L., Gunn, T., Mishra, A., Pulwarty, R. S. and Sheffield, J., 2019. Droughts in the Anthropocene/Les sécheresses dans l'Anthropocène. UNESCO and GRID-Arendal. https://unesdoc.unesco.org/ark:/48223/pf0000371410.locale=en

6 IIRR, Acacia Consultants, Cordaid, 2008. Drought Cycle Management: A toolkit for the drylands of the Greater Horn. International Institute for Rural Reconstruction, Nairobi,

7 King-Okumu, C., Tsegai, D., Sanogo, D., Kiprop, J., Cheboiwo, J., Sarr, M.S., da Cunha, M.I. and Salman, M., 2021. How can we stop the slow-burning systemic fuse of loss and damage due to land degradation and drought in Africa? Current Opinion in Environmental Sustainability, 50, pp.289-302. https://doi.org/10.1016/j.cosust.2021.04.008

8 United Nations Office for Disaster Risk Reduction, 2021. GAR Special Report on Drought 2021. Geneva https://www.undrr.org/publication/gar-special-report-drought-2021

9 Aguilar-Barajas, I., Sisto, N.P., Magaña-Rueda, V., Ramírez, A.I. and Mahlknecht, J., 2016. Drought policy in Mexico: A long, slow march toward an integrated and preventive management model. Water Policy, 18(S2), pp.107-121. https://doi.org/10.2166/wp.2016.116

10 McNutt, C., M. Hayes, L. Darby, J. Verdin, and R. Pulwarty, 2013. Developing Early Warning and Drought Risk Reduction Strategies. In: Botterill, L.C., & Cockfield, G. eds., Drought, Risk Management, and Policy: Decision-Making Under Uncertainty (1st ed.). CRC Press. https://doi.org/10.1201/b14918

11 Campos, J.N.B., 2015. Paradigms and public policies on drought in Northeast Brazil: a historical perspective. Environmental Management, 55, pp.1052-1063. https://doi.org/10.1007/s00267-015-0444-x

12 Megalhaes A., 2018. Towards national drought policies in Latin America and the Caribbean Region -White Paper. UNCCD, WMO, FAO eds., Bonn, UNCCD. https://knowledge.unccd.int/publication/towards-national-drought-policies-latin-america-and-caribbean-white-paper

13 King-Okumu, C. 2021. A rapid review of drought risk mitigation measures – Integrated drought management. Rome, FAO. https://doi.org/10.4060/cb7085en

14 Gidey, E., Gebregergis, T., Zeweld, W., Gebretsadik, H., Dikinya, O. and Mussa, S., 2021. Farmer's drought response and coping strategies at household level in southern Tigray, Ethiopia. https://doi.org/10.21203/rs.3.rs-401869/v1

15 RELMA, 2005. Managing land: A practical guidebook for development agents in Ethiopia. Regional Land Management Unit. http://apps.worldagroforestry.org/downloads/Publications/PDFS/MN13598.pdf

16 Makumba, W.I.H., Janssen, B., Oenema, O., Akinnifesi, F., Mweta, D., Kwesiga, F.R. 2006. The long-term effects of a gliricidia-maize intercropping system in southern Malawi, on gliricidia and maize yields, and soil properties. Agriculture, Ecosystems and Environment. Volume 116 (2006) 1-2. Pages 85-92. https://doi.org/10.1016/j.agee.2006.03.012

17 Mufute, O., 2020. Turning to conservation as severe droughts, food insecurity spike. African Wildlife Foundation. https://www.awf.org/news/turning-conservation-severe-droughts-food-insecurity-spike

18 Wilcox, K.R., Koerner, S.E., Hoover, D.L., Borkenhagen, A.K., Burkepile, D.E., Collins, S.L., Hoffman, A., Kirkman, K.P., Knapp, A.K., Strydom, T., Thompson, D.I., and Smith, M.D. 2020. Rapid recovery of ecosystem function following extreme drought in a South African savanna grassland. Ecology 101(4). https://doi.org/10.1002/ecy.2983

19 Mufute, O., 2020. Turning to conservation as severe droughts, food insecurity spike. African Wildlife Foundation. https://www.awf.org/news/turning-conservation-severe-droughts-food-insecurity-spike

20 Margrath, J., 2020. Regreening the Sahel: a quiet agroecological evolution. Oxfam. https://policy-practice.oxfam.org/resources/regreening-the-sahel-a-quiet-agroecological-evolution-621091

21 Tullstorpsåprojektet webpage. https://www.tullstorpsan.se/english

22 European Environment Agency. 2021. Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction. European Environment Agency. Copenhagen, 159 pp. https://www.eea.europa.eu/publications/nature-based-solutions-in-europe

23 DW, 2019. Germany mulls funding massive €800 million reforestation effort. Deutsche Welle (25 September). https://p.dw.com/p/3QECp

24 Thünen Institute, (n.d.). Forest damage due to drought and heat FAQ. https://www.thuenen.de/en/topics/forests/forest-monitoring-more-than-just-data/forest-damage-due-to-drought-and-heat

25 Memon, J.A., Jogezai, G., Hussain, A., Alizai, M.Q. and Baloch, M.A., 2017. Rehabilitating traditional irrigation systems: assessing popular support for Karez rehabilitation in Balochistan, Pakistan. Human Ecology, 45(2), pp.265-275. https://doi.org/10.1007/s10745-016-9890-1

26 Shah, T., 2014. Towards a Managed Aquifer Recharge Strategy for Gujarat, India: An Economist's Dialogue with Hydro-Geologists. Journal of Hydrology 518. Part A, 94–107. https://doi.org/10.1016/j.jhydrol.2013.12.022

27 Pavelic, P., 2020. Mitigating floods for managing droughts through aquifer storage. An examination of two complementary approaches. Water Knowledge Note. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/33244

28 Bunsen, J.; Rathod, R., 2016. Pipe assisted underground taming of surface floods: The experience with Holiyas in North Gujarat. Gujarat, India: IWMI-Tata Water Policy Research Program. 8p. http://www.iwmi.cgiar.org/iwmi-tata/PDFs/iwmi-tata_water_policy_research_highlight-issue_02_2016.pdf

29 UNFCC – Momentum for Change POSTCAST, 2016. Building agricultural resilience by harvesting rainwater in India. https://unfccc.int/news/building-agricultural-resilience-by-harvesting-rainwater-in-india

30 Ngumbi E., 2019. Becoming Drought Resilient: Why African Farmers Must Consider Drought Tolerant Crops. Reliefweb (15 March) https://reliefweb.int/report/world/becoming-drought-resilient-why-african-farmers-must-consider-drought-tolerant-crops

31 Ndimubandi, J., 2019. Capitalisation sur les approches de mise œuvre de deux projets : Projet d'Amélioration Durable de l'Accès aux Semences, aux Intrants et Outillage agricole dans 3 communes de la région du Moso (PADASIO), et Projet de Promotion de la Production des plantes Résistantes à la sécheresse (PRORES-KIRIZUBAMUGENZI). Bujumbura, Louvain Coopération. https://www.louvaincooperation.org/sites/default/files/2019-10/109.CAPITALISATION%20PADASIO-PRORES%20%28VF%20Imprim%C3%A9e%29.pdf

32 Lunduka, R.W., Mateva, K.I., Magorokosho, C. and Manjeru, P., 2019. Impact of adoption of drought-tolerant maize varieties on total maize production in south Eastern Zimbabwe. Climate and development, 11(1), pp.35-46. https://doi.org/10.1080/17565529.2017.1372269

33 Vaiknoras, K., Larochelle, C., and Alwang, J., 2020. How the adoption of drought-tolerant rice varieties impacts households in a non-drought year: Evidence from Nepal. IFAD Research Series 64. Rome. https://www.ifad.org/en/web/knowledge/-/publication/research-series-issue-64-how-the-adoption-of-drought-tolerant-rice-varieties-impacts-households-in-a-non-drought-year-evidence-from-nepa

34 Marquez C.M., 2015. Central America tests drought-resistant 'miracle' beans. PHYS (1 December). https://phys.org/news/2015-12-central-america-drought-resistant-miracle-beans.html

35 Centro Nacional de Tecnología Agropecuaria y Forestal "Enrique Álvarez Córdova" CENTA, 2015. "CENTA EAC" variedad de frijol color rojo claro. http://arsftfbean.uprm.edu/bean/wp-content/uploads/2020/02/CENTA-EAC-nueva-variedad-de-frijol-rojo-claro-2015.pdf

36 Instituto de Ciencia y Tecnología Agrícolas Guatemala. 2017. ICTA Chortí: Variedad de frijol arbustivo Biofortificada con hierro y zinc. https://www.icta.gob.gt/publicaciones/Frijol/ICTA%20Chorti%20ACM%20Varieda%20de%20frijol%20arbustivo%20biofortificado%20con%20hierro%20y%20zinc,%202017.pdf

37 CIAT Comunicaciones, 2020. A wild beans' genes may help a key crop thrive on a hotter Earth. CIAT Blog (23 January). https://blog.ciat.cgiar.org/a-wild-beans-genes-may-help-a-key-crop-thrive-on-a-hotter-earth

38 Guerrero-Zurita, F., Ramírez, D.A., Rinza, J., Ninanya, J., Blas, R. and Heider, B., 2020. Potential short-term memory induction as a promising method for increasing drought tolerance in sweet potato crop wild relatives [Ipomoea series Batatas (Choisy) D. F. Austin]. Frontiers Plant Science, 11, 567507. https://doi.org/10.3389/fpls.2020.567507

39 World Meteorological Organization (WMO) and Global Water Partnership (GWP), 2017. Benefits of action and costs of inaction: Drought mitigation and preparedness – a literature review (N. Gerber and A. Mirzabaev). Integrated Drought Management Programme (IDMP) Working Paper 1. WMO, Geneva, and GWP, Stockholm. https://library.wmo.int/doc_num.php?explnum_id=3401

40 McDonald, R.I., Weber, K., Padowski, J., Flörke, M., Schneider, C., Green, P.A., Gleeson, T., Eckman, S., Lehner, B., Balk, D. and Boucher, T., 2014. Water on an urban planet: Urbanization and the reach of urban water infrastructure. Global environmental change, 27, pp.96-105. https://doi.org/10.1016/j.gloenvcha.2014.04.022

41 Zhang X, Chen N, Sheng H, Ip C, Yang L, Chen Y, Sang Z, Tadesse T, Lim TPY, Rajabifard A, Bueti C, Zeng L, Wardlow B, Wang S, Tang S, Xiong Z, Li D, Niyogi D., 2019. Urban drought challenge to 2030 sustainable development goals. Sci Total Environ. 693, 133536. https://doi.org/10.1016/j.scitotenv.2019.07.342

42 Matikinca P., Ziervogel G., Enqvist J., 2020. Drought response impacts on household water use practices in Cape Town, South Africa. Water Policy 22 (3): 483–500. https://doi.org/10.2166/wp.2020.169

43 UNICEF. 2021. Urban water scarcity guidance note: Preventing day zero. UNICEF. https://www.unicef.org/documents/urban-water-scarcity-guidance-note

44 Pickrell J., 2021, A year after Australia's wildfires, extinction threatens hundreds of species. Science News (9 March). https://www.sciencenews.org/article/australia-wildfires-extinction-threat-species-one-year-later

45 YourHome, (n.d.) Australia's Guide to environmentally sustainable homes: Rainwater Key points. https://www.yourhome.gov.au/water/rainwater

46 Browder, G., Nunez Sanchez, A., Jongman, B., Engle, N., van Beek, E., Castera Errea, M., Hodgson, S., 2021. An EPIC Response: Innovative Governance for Flood and Drought Risk Management. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/35754

47 UNEP, 2021. Progress on Integrated Water Resources Management. Tracking SDG 6 series: global indicator 6.5.1 updates and acceleration needs. https://wedocs.unep.org/bitstream/handle/20.500.11822/36690/PIWRS6.5.1.pdf

48 UNESCO CliMWaR Project, (n.d.) Enhancing Climate Services for Improved Water Management. https://en.unesco.org/climwar

49 WMO, (n.d.) Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin (VFDM) Regional Project. https://public.wmo.int/en/projects/integrating-flood-and-drought-management-and-early-warning-climate-change-adaptation-0

50 UN Watercourses Convention, (n.d.) User's guide fact sheet series: Number 4, Equitable and reasonable utilization. http://www.unwatercoursesconvention.org/documents/UNWC-Fact-Sheet-4-Equitable-and-Reasonable-Utilisation.pdf

51 Sara J.J., Borgomeo E., Jagerskog A., 2021, Measuring success in transboundary water cooperation: Lesson from World Bank engagements. World Bank Blogs (07 October). https://blogs.worldbank.org/water/measuring-success-transboundary-water-cooperation-lessons-world-bank-engagements

52 Bukowski, J., 2011. Sharing water on the Iberian peninsula: A Europeanisation approach to explaining transboundary cooperation. Water Alternatives 4(2): 171-196. https://www.water-alternatives.org/index.php/alldoc/articles/vol4/v4issue2/138-a4-2-5/file

53 Agreement on Cooperation for the Protection and Sustainable Use of the Waters of the Spanish-Portuguese Hydrographic Basins, 1998. http://www.cawater-info.net/bk/water_law/pdf/spain_portugal_en.pdf

54 Sindico, F., 2020. International law and transboundary aquifers, Edward Elgar Publishing Limited, UK.

55 UN-ESCWA and BGR (United Nations Economic and Social Commission for Western Asia; Bundesanstalt für Geowissenschaften und Rohstoffe), 2013. Inventory of Shared Water Resources in Western Asia. Beirut. https://www.unescwa.org/publications/inventory-shared-water-resources-western-asia

56 Disi water conveyance project, 2017. MEED (02 May). https://www.meed.com/disi-water-conveyance-project

57 Long, B.R., 2003. Middle East Water Conflict: the battle over the Al-Disi Aquifer, ICE Case studies, number 124, https://mandalaprojects.com/ice/ice-cases/aquifer.htm

58 Müller, M. F., Müller-Itten, M. C., and Gorelick, S. M., 2017. How Jordan and Saudi Arabia are avoiding a tragedy of the commons over shared groundwater, Water Resources Research., 53, 5451–5468 https://doi.org/10.1002/2016WR020261

59 Eckstein, G., 2015. The newest transboundary aquifer agreement: Jordan and Saudi Arabia cooperate over the Al-Sag-Al-Disi aquifer, International Water Law Project. https://www.internationalwaterlaw.org/blog/2015/08/31/the-newest-transboundary-aquifer-agreement-jordan-and-saudi-arabia-cooperate-over-the-al-sag-al-disi-aquifer

60 Agreement Between the Government of the Hashemite Kingdom of Jordan and the Government of the Kingdom of Saudi Arabia for the Management and Utilization of the Ground Waters in the Al-Sag/Al-Disi Layer, signed in Riyadh on 30 April 2015. (Unofficial English translation). http://internationalwaterlaw.org/documents/regionaldocs/Disi_Aquifer_Agreement-English2015.pdf

61 World Resources Institute, 2020. New Data Shows Millions of People, Trillions in Property at Risk from Flooding — But Infrastructure Investments Now Can Significantly Lower Flood Risk, Press Release (23 April). https://www.wri.org/news/release-new-data-shows-millions-people-trillions-property-risk-flooding-infrastructure

62 UNEP, 2020. How climate change is making record-breaking floods the new normal, (03 March). https://www.unep.org/news-and-stories/story/how-climate-change-making-record-breaking-floods-new-normal

63 World Resources Institute, 2020. New Data Shows Millions of People, Trillions in Property at Risk from Flooding — But Infrastructure Investments Now Can Significantly Lower Flood Risk, Press Release (23 April). https://www.wri.org/news/release-new-data-shows-millions-people-trillions-property-risk-flooding-infrastructure

64 Rey, F., 2021. Harmonizing Erosion Control and Flood Prevention with Restoration of Biodiversity through Ecological Engineering Used for Co-Benefits Nature-Based Solutions. Sustainability, 13(20), p.11150. https://doi.org/10.3390/su132011150

65 Seddon, N., Chausson, A., Berry, P., Girardin, C. A., Smith, A., & Turner, B., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philosophical Transactions of the Royal Society B, 375(1794), 20190120. https://doi.org/10.1098/rstb.2019.0120

66 World Bank, 2017. Implementing nature-based flood protection: Principles and implementation guidance. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/28837

67 Hou-Jones, X., Roe, D., and Holland, E., 2021. Nature-based Solutions in Action: Lessons from the Frontline. CAN, Bonn. https://pubs.iied.org/20451g

68 Yu, X., Jiang, L., Li, L., Wang, J., Wang, L., Lei, G., & Pittock, J., 2011. Freshwater management and climate change adaptation: experiences from the central Yangtze in China. Climate and Development, 1(3), 241-248. https://doi.org/10.3763/cdev.2009.0023

69 Global Facility for Disaster Reduction and Recovery, 2016. Reducing Colombo's Flood Risk: GFDRR (September). https://www.gfdrr.org/en/feature-story/reducing-colombos-flood-risk

70 Global Facility for Disaster Reduction and Recovery, 2018. Results in Resilience: Urban wetlands management in Colombo: A new model for urban resilience. (02 April) Washington DC. https://www.gfdrr.org/en/publication/results-resilience-urban-wetlands-management-colombo

71 Climate-KIC, 2020. Nature-Based Solutions for Water - Webinar 3. Nature-Based City Initiative. https://www.youtube.com/watch?v=Jlzqva3cG5M

72 Loupis, M., 2020. OAL Greece Co-developing NBS against Flood and Water Scarcity. Presentation at Nature-Based Solutions for Water - Webinar 3. Nature-Based City Initiative. https://www.youtube.com/watch?v=Jlzqva3cG5M

73 Spyrou, C., Loupis, M., Charizopoulos, N., Apostolidou, I., Mentzafou, A., Varlas, G., Papadopoulos, A., Dimitriou, E., Panga, D., Gkeka, L., Bowyer, P., Pfeifer, S., Debele, S.E. and Kumar, P., 2021. Evaluating Nature-Based Solution for Flood Reduction in Spercheios River Basin under Current and Future Climate Conditions. Sustainability, 13(7), p.3885. https://doi.org/10.3390/su13073885

74 The World Bank, 2018. Helping Mozambique Cities Build Resilience to Climate Change. World Bank (05 June). https://www.worldbank.org/en/news/feature/2018/06/05/helping-mozambique-cities-build-resilience-to-climate-change

75 Earthworks Landscape Architects, 2017. Chiveve River Beira Mozambique. Earthworks Landscape Architects. https://www.elastudio.co.za/project/chiveve-river-beira-mozambique

76 Carvalho, R., 2020. Mozambique inaugurates largest urban park in Africa. FurtherAfrica (20 December). https://furtherafrica.com/2020/12/20/mozambique-inaugurates-largest-urban-park-in-africa

77 Magoum, I., 2020. Mozambique: The State creates a "green" park in Beira to fight against floods. Afrik 21 (31 December). https://www.afrik21.africa/en/mozambique-the-state-creates-a-green-park-in-beira-to-fight-against-floods

78 Mansoor, S., Farooq, I., Kachroo, M.M., Mahmoud, A.E.D., Fawzy, M., Popescu, S.M., Alyemeni, M.N., Sonne, C., Rinklebe, J. and Ahmad, P., 2022. Elevation in wildfire frequencies with respect to the climate change. Journal of environmental management, 301, p.113769. https://doi.org/10.1016/j.jenvman.2021.113769

79 Stein, S. M., Menakis, J., Carr, M. A., Comas, S. J., Stewart, S. I., Cleveland, H., ... & Radeloff, V. C., 2013. Wildfire, wildlands, and people: understanding and preparing for wildfire in the wildland-urban interface-a Forests on the Edge report. Gen. Tech. Rep. RMRS-GTR-299. Fort Collins, CO. US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 36 p. https://doi.org/10.1016/j.jenvman.2021.113769

80 The Nature Conservancy, 2019. Wildfires and Forest Management. The Nature Conservancy (27 August). https://www.nature.org/en-us/about-us/where-we-work/united-states/idaho/stories-in-idaho/wildfires-and-forest-management

81 Buono, P., 2020. Quiet Fire: Indigenous tribes in California and other parts of the U.S. have been rekindling the ancient art of controlled burning. The Nature Conservancy (02 November). https://www.nature.org/en-us/magazine/magazine-articles/indigenous-controlled-burns-california

82 Mistry, J., Bilbao, B.A. and Berardi, A., 2016. Community owned solutions for fire management in tropical ecosystems: case studies from Indigenous communities of South America. Philosophical Transactions of the Royal Society B: Biological Sciences, 371(1696), p.20150174. https://doi.org/10.1098/rstb.2015.0174

83 Rewilding Europe, 2021. Grazing to minimise wildfire risk. GrazeLIFE (29 January). https://grazelife.com/blog/grazing-to-minimise-wildfire-risk

84 Schoennagel, T., Balch, J.K., Brenkert-Smith, H., Dennison, P.E., Harvey, B.J., Krawchuk, M.A., Mietkiewicz, N., Morgan, P., Moritz, M.A., Rasker, R., Turner, M.G. and Whitlock, C., 2017. Adapt to more wildfire in western North American forests as climate changes. Proceedings of the National Academy of Sciences, [online] 114(18), pp.4582–4590. https://doi.org/10.1073/pnas.1617464114

85 Landscape Level Collaboration, (n.d.) Fire Risk Reduction by Collaboration in California's Dinkey Creek https://landscapecollaboration.org/case-studies/fire-risk-reduction-collaboration-californias-dinkey-creek

86 Landscape-Level Collaboration, (n.d.) Restoring Cultural Landscapes and Reducing Community Fire Risk in New Mexico | Landscape-Level Collaboration. https://landscapecollaboration.org/case-studies/restoring-cultural-landscapes-and-reducing-community-fire-risk-new-mexico

87 Landscape-Level Collaboration, (n.d.) Oregon Community Wildfire Preparedness Complements Deschutes Forest Collaborative Hazardous Fuel Removal. https://landscapecollaboration.org/case-studies/oregon-community-wildfire-preparedness-complements-deschutes-forest-collaborative

88 The Nature Conservancy, 2019. Controlled Burning 101. The Nature Conservancy (3 May) https://www.nature.org/en-us/about-us/where-we-work/united-states/oregon/stories-in-oregon/why-do-a-controlled-burn

89 Landscape-Level Collaboration, (n.d.) Case Studies https://landscapecollaboration.org/case-studies

90 Stein, S. M., Menakis, J., Carr, M. A., Comas, S. J., Stewart, S. I., Cleveland, H., Bramwell L., & Radeloff, V. C., 2013. Wildfire, wildlands, and people: understanding and preparing for wildfire in the wildland-urban interface-a Forests on the Edge report. Gen. Tech. Rep. RMRS-GTR-299. Fort Collins, CO. US Department of Agriculture, Forest Service, Rocky Mountain Research Station. 36 p. https://doi.org/10.2737/RMRS-GTR-299

91 Grazelife, 2019. GrazeLIFE | Grazing for wildfire prevention, ecosystem services, biodiversity and landscape management. GrazeLIFE. https://grazelife.com

92 Rouet-Leduc, J., Pe'er, G., Moreira, F., Bonn, A., Helmer, W., Shahsavan Zadeh, S.A.A., Zizka, A. and van der Plas, F., 2021. Effects of large herbivores on fire regimes and wildfire mitigation. Journal of Applied Ecology. https://doi.org/10.1111/1365-2664.13972

93 Rewilding Europe, 2011. The Grazing Fire Brigade (10 August). https://rewildingeurope.com/blog/the-grazing-fire-brigade

94 Grazelife, 2021. Grazing to minimise wildfire risk (29 January). https://grazelife.com/blog/grazing-to-minimise-wildfire-risk

95 UNFCCC, 2019. Restoring Peatlands in Russia: Russia, UNFCCC. https://unfccc.int/climate-action/momentum-for-change/planetary-health/restoring-peatlands-in-russia-i-russia

96 Graham, C. and Streed, E., 2016. Helping Indonesia Fight Catastrophic Forest Fires. FrontLines March/April 2016, U.S. Agency for International Development. https://www.usaid.gov/news-information/frontlines/march-april-2016/helping-indonesia-fight-catastrophic-forest-fires

97 International Climate Initiative (IKI), 2021. Restoring Peatlands in Russia - for fire prevention and climate change mitigation. https://www.international-climate-initiative.com/en/details/project/restoring-peatlands-in-russia-for-fire-prevention-and-climate-change-mitigation-11_III_040-117

98 The Nature Conservancy Australia, 2021. Fighting fire with fire. https://www.natureaustralia.org.au/what-we-do/our-priorities/climate-change/climate-change-stories/fighting-fire-with-fire

99 Bowman, D., Lehman, G. and Sculthorpe, A., 2020. What Aboriginal Australians can teach us about managing wildfires. The World from PRX. https://www.pri.org/stories/2020-08-27/what-aboriginal-australians-can-teach-us-about-managing-wildfires

100 Freeman, D., Williamson, B. and Weir, J., 2021. Cultural burning and public sector practice in the Australian Capital Territory. Australian Geographer, 52(2), pp.111–129. https://doi.org/10.1080/00049182.2021.1917133

101 Allam, L., 2020. Right fire for right future: how cultural burning can protect Australia from catastrophic blazes. The Guardian. (18 January) https://www.theguardian.com/australia-news/2020/jan/19/right-fire-for-right-future-how-cultural-burning-can-protect-australia-from-catastrophic-blazes

102 Altman, J. and Fisher, R., 2020. The world's best fire management system is in northern Australia, and it's led by Indigenous land managers. The Conversation (10 March). https://theconversation.com/the-worlds-best-fire-management-system-is-in-northern-australia-and-its-led-by-indigenous-land-managers-133071

103 Murphy, B., 2013. Savanna burning: carbon pays for conservation in northern Australia. The Conversation (21 February). https://theconversation.com/savanna-burning-carbon-pays-for-conservation-in-northern-australia-12185

104 Middleton, N. and Kang, U., 2017. Sand and Dust Storms: Impact Mitigation. Sustainability, 9(6), p.1053. https://doi.org/10.3390/su9061053

105 UNEP, WMO, and UNCCD, 2016. Global Assessment of Sand and Dust Storms. United Nations Environment Programme, Nairobi. https://wedocs.unep.org/handle/20.500.11822/7681

106 Ministry of Agriculture, Republic of Iraq, 2017. Land Degradation Neutrality Target Setting National Report. UNCCD. https://knowledge.unccd.int/sites/default/files/ldn_targets/2019-08/Iraq%20LDN%20TSP%20Country%20Report.pdf

107 National Forestry and Grassland Administration China, 2019. Phase II of Beijing Tianjin Sandstorm Source Control Project. UNEP Document Repository, pp.1–6. https://wedocs.unep.org/bitstream/handle/20.500.11822/29776/Sandstorm.pdf

108 CGTN, 2020. Counties benefit from Beijing-Tianjin sandstorm source control project. CGTN (27 September) https://news.cgtn.com/news/2020-09-27/Counties-benefit-from-Beijing-Tianjin-sandstorm-source-control-project-U7wvmur4Zy/index.html

109 Al-Dousari, A.M., Ahmed, M., Al-Dousari, N. and Al-Awadhi, S., 2018. Environmental and economic importance of native plants and green belts in controlling mobile sand and dust hazards. International Journal of Environmental Science and Technology, 16(5), pp.2415–2426. https://doi.org/10.1007/s13762-018-1879-4

110 Barcelona Supercomputing Center, 2018. BSC and AEMET operate the new Early Warning Advisory System for Sand and Dust Storm in Burkina Faso. BSC (30 October) https://www.bsc.es/news/bsc-news/bsc-and-aemet-operate-the-new-early-warning-advisory-system-sand-and-dust-storm-burkina-faso

111 Columbia University, 2019. The Aral Sea Crisis. http://www.columbia.edu/~tmt2120/introduction.htm

112 Indoitu, R., Kozhoridze, G., Batyrbaeva, M., Vitkovskaya, I., Orlovsky, N., Blumberg, D., & Orlovsky, L., 2015. Dust emission and environmental changes in the dried bottom of the Aral Sea. Aeolian Research, 17, 101-115. https://doi.org/10.1016/j.aeolia.2015.02.004

113 UNCCD, (n.d.) Regional approaches to combat drought, sand and dust storms in Central Asia. UNCCD. https://www.unccd.int/conventionregions/regional-approaches-combat-drought-sand-and-dust-storms-central-asia

114 Committee on Food Security, 2012. Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. FAO, Rome. https://www.fao.org/publications/card/en/c/I2801E

115 Anseeuw, W. and Baldinelli, G.M., 2020. Uneven Ground. Land Inequality at the Heart of Unequal Societies. Synthesis Report. Rome, Italy: International Land Coalition, OXFAM, Welt Hunger Hilfe. https://www.landcoalition.org/en/uneven-ground/report-and-papers

116 FAO, 2021. The State of the World's Land and Water Resources for Food and Agriculture (SOLAW) – Systems at breaking point. Synthesis report 2021. Rome. https://www.fao.org/land-water/solaw2021/en

117 Committee on Food Security, 2012. Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. FAO, Rome. https://www.fao.org/publications/card/en/c/I2801E

118 UNCCD, 2019. Decision 26/COP.14 https://www.unccd.int/sites/default/files/sessions/documents/2019-11/26-cop14.pdf

119 Cowie, A.L., Orr, B.J., Sanchez, V.M.C., Chasek, P., Crossman, N.D., Erlewein, A., Louwagie, G., Maron, M., Metternicht, G.I., Minelli, S. and Tengberg, A.E., 2018. Land in balance: The scientific conceptual framework for Land Degradation Neutrality. Environmental Science & Policy, 79, pp.25-35. https://doi.org/10.1016/j.envsci.2017.10.011

120 FAO and UNCCD, 2022. Technical Guide on the Integration of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security into the Implementation of the UNCCD and Land Degradation Neutrality. FAO, Rome and UNCCD, Bonn.

121 Committee on Food Security, 2012. Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security. FAO, Rome. https://www.fao.org/publications/card/en/c/I2801E

122 IUCN, (n.d.) The Restoration Initiative. Projects: Cameroon. https://www.iucn.org/restoration-initiative/projects/cameroon

123 McLain, R., Lawry, S., Guariguata, M.R. and Reed, J., 2021. Toward a tenure-responsive approach to forest landscape restoration: A proposed tenure diagnostic for assessing restoration opportunities. Land Use Policy, 104. https://doi.org/10.1016/j.landusepol.2018.11.053

124 IUCN, (n.d.) The Restoration Initiative. Projects: China https://www.iucn.org/restoration-initiative/projects/china

125 IUCN, (n.d.) The Restoration Initiative. Projects: Myanmar https://www.iucn.org/restoration-initiative/projects/myanmar

126 IUCN, (n.d.) The Restoration Initiative. Projects: Pakistan https://www.iucn.org/restoration-initiative/projects/pakistan

127 FAO, 2021. Evaluation of projects related to the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security funded by Germany. Programme Evaluation Series 05/21. Rome. https://www.fao.org/documents/card/en/c/cb4876en

128 FAO, 2020. Sustaining land governance reforms: Lessons from the European Union Land Governance Programme. Rome. https://www.fao.org/documents/card/en/c/cb1741en

129 Jansen, L.J.M., Kalas, P.P., and Bicchieri, M., 2021. Improving governance of tenure in policy and practice: The case of Myanmar. Land Use Policy 100,104906. https://doi.org/10.1016/j.landusepol.2020.104906

130 FAO, 2021. Evaluation of projects related to the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security funded by Germany. Programme Evaluation Series 05/21. Rome. https://www.fao.org/documents/card/en/c/cb4876en

131 Hall, R., Scoones, I. and Henley, G., 2016. Strengthening Land Governance: Lessons from implementing the Voluntary Guidelines. LEGEND State of the Debate Report 2016. https://landportal.org/sites/landportal.info/files/Strengthening%20Land%20Governance.pdf

132 Global Donor Working Group on Land, (n.d.) Land Governance Programme Map & Database. https://landgov.donorplatform.org

133 Jansen, L.J.M., 2020. Improving governance of tenure and practice: monitoring in a space for multiple views. Sustainability 12(23), 9896. https://doi.org/10.3390/su12239896

134 Unruh, J.D., Akhobadze, S., Ibrahim, H.O., Karapinar, B., Kusum, B.S., Montoiro, M., and Santivane, M.S., 2019. Land tenure in support of land degradation neutrality. Land Tenure Journal no.2-19. Rome, FAO. https://www.fao.org/documents/card/fr/c/CA5354EN

135 FAO, 2020. The Voluntary Guidelines: securing our rights - Senegal River Basin. Rome. https://www.fao.org/documents/card/en/c/ca9813en

136 International Waters Governance, (n.d.) Senegal River Basin. http://www.internationalwatersgovernance.com/senegal-river-basin.html

137 Aggarwal, S., Larson, A., McDermott, C., Katila, P., and Giessen, L., 2021. Tenure reform for better forestry: An unfinished policy agenda Open Access. Forest Policy and Economics 123 (2), 102376. https://doi.org/10.1016/j.forpol.2020.102376

138 FAO, 2020. Development of National Land Banks for Improved Food and Nutrition Security and Land Administration in Grenada, Saint Lucia and Saint Vincent and the Grenadines - TCP/SLC/3602. Rome. http://www.fao.org/documents/card/en/c/CB3185EN

139 FAO, 2019. The Voluntary Guidelines: Securing our Rights Sierra Leone. Success Stories. FAO, Rome. https://www.fao.org/documents/card/fr/c/CA2687EN

140 FAO and UNCCD, 2022. Technical Guide on the Integration of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security into the Implementation of the UNCCD and Land Degradation Neutrality. FAO, Rome and UNCCD, Bonn.

141 UNCCD-SPI, 2022. The contribution of integrated land use planning and integrated landscape management to implementing land degradation neutrality: entry points and support tools. UNCCD Science-Policy Interface, Bonn.

142 Chigbu, U., Alemayehu, Z. and Dachaga, W., 2019. Uncovering land tenure insecurities: Tips for tenure responsive land-use planning in Ethiopia. Development in Practice, 29(3), pp.371-383. https://doi.org/10.1080/09614524.2019.1567688

143 FAO, 2020. Strengthening civic spaces in spatial planning processes. Governance of Tenure Technical Guide No. 12. FAO, Rome. https://www.fao.org/documents/card/en/c/cb0422en

144 Chigbu, U.E., Ntihinyurwa, P.D., de Vries, W.T. and Ngenzi, E.I., 2019. Why tenure responsive land-use planning matters: Insights for land use consolidation for food security in Rwanda. International journal of environmental research and public health, 16(8), p.1354. https://doi.org/10.3390/ijerph16081354

145 Strassburg, B.B., Iribarrem, A., Beyer, H.L., Cordeiro, C.L., Crouzeilles, R., Jakovac, C.C., Junqueira, A.B., Lacerda, E., Latawiec, A.E., Balmford, A. and Brooks, T.M., 2020. Global priority areas for ecosystem restoration. Nature, 586(7831), pp.724-729. https://doi.org/10.1038/s41586-020-2784-9

146 Brancalion, P.H.S., Niamir, A., Broadbent, E., Crouzeilles, R., Barros, F.S., Zambrano, A.M.A., Baccini, A., Aronson, J., Goetz, S., Reid, J.L. and Strassburg, B.B., 2019. Global restoration opportunities in tropical rainforest landscapes. Science advances, 5(7), p.eaav3223. https://doi.org/10.1126/sciadv.aav3223

147 FAO, 2016. Negotiated territorial development in a multi-stakeholder participatory resource planning approach: An Initial Sustainable Framework for the Near East Region. Land and Water Division Working Paper 15. FAO, Rome. https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1274428

148 Kaim, A., B. Bartkowski, N. Lienhoop, C. Schröter-Schlaack, M. Volk, and M. Strauch, 2021. Combining biophysical optimization with economic preference analysis for agricultural land-use allocation. Ecology and Society 26(1):9 https://doi.org/10.5751/ES-12116-260109

149 Asian Development Bank, Greater Mekong Subregion Environment Operations Center, 2018. Innovations in land use planning in the greater Mekong Subregion. ADB, Bangkok. https://www.adb.org/publications/innovations-land-use-planning-gms

150 Department of Land Conservation and Development, Oregon State, (n.d.) Maps, Data and Tools. https://www.oregon.gov/lcd/About/Pages/Maps-Data-Tools.aspx

151 Dempsey J.A., Plantinga A.J., Kline J.D., Lawler J.J., Martinuzzi S., Radeloff V.C., Bigelow D.P., 2017. Effects of local land-use planning on development and disturbance in riparian areas, Land Use Policy, 60: 16-25. https://doi.org/10.1016/j.landusepol.2016.10.011

152 FAO, (n.d.) Regional Office for Latin America and the Caribbean: Mainstreaming Sustainable Land Development and Management (SLDM) Project in Guyana. http://www.fao.org/americas/noticias/ver/en/c/1402089

153 da Silva, R.F.B., Rodrigues, M.D.A., Vieira, S.A., Batistella, M., and Farinaci, J., 2017. Perspectives for environmental conservation and ecosystem services on coupled rural-urban systems. Perspectives in Ecology and Conservation, 15(2), pp. 74-81. https://doi.org/10.1016/j.pecon.2017.05.005

154 Sylla, M., Hagemann, N., and Szewranski, S., 2020. Mapping trade-offs and synergies among peri-urban ecosystem services to address spatial policy. Environmental Science and Policy, 112, pp 79-90. https://doi.org/10.1016/j.envsci.2020.06.002

155 UN-Habitat, 2020. Compendium of case studies for the implementation of the "urban-rural linkages: Guiding principles (URL-GP) and framework for action." First Edition, Nairobi. https://unhabitat.org/sites/default/files/2020/06/compendium-of-url-case-studies_web-vers_.pdf

156 UN-Habitat, 2020. Compendium of case studies for the implementation of the "urban-rural linkages: Guiding principles (URL-GP) and framework for action." First Edition, Nairobi. https://unhabitat.org/sites/default/files/2020/06/compendium-of-url-case-studies_web-vers_.pdf

157 Berkhout, E., Kodsi, E., van den Berg, M., van Zeist, W., Mwandendu, R., van der Esch, S., Rembold, F., Meroni, M., Cherlet, M., 2021. Future Perspectives on Land for Eastern Africa: Pilot Study Focusing on Ethiopia and Kenya. UNDP, Nairobi. https://www1.undp.org/content/nairobi-gc-red/en/home/library/combatting-land-degradation---securing-a-sustainable-future1.html

158 Elias, M., Joshi, D., and Meinzen-Dick, R. S., 2021. Restoration for whom, by whom? A feminist political ecology of restoration. Ecological Restoration 39(1-2): 3-15. https://doi.org/10.3368/er.39.1-2.3

159 James, R., Gibbs, B., Whitford, L., Leisher, C., Konia, R., and Butt, N., 2021. Conservation and natural resource management: Where are all the women? Oryx, 1-8. https://doi.org/10.1017/s0030605320001349

160 Broeckhoven, N. and Cliquet, A., 2015. Gender and ecological restoration: time to connect the dots. Restoration Ecology, 23(6), pp.729-736. https://doi.org/10.1111/rec.12270

161 Mukasa, C., Tibazalika, A., Mwangi, E., Banana, A. Y., Bomuhangi, A., & Bushoborozi, J., 2016. Strengthening women's tenure rights and participation in community forestry. Center for International Forestry Research info brief 155, 7pp. https://doi.org/10.17528/cifor/006249

162 Arora-Jonsson, S., Agarwal, S., Pierce Colfer, C. J., Keene, S., Kurian, P. and Larson, A. M., 2019. "SDG 5: Gender Equality – A Precondition for Sustainable Forestry," in Katila, P., Pierce Colfer, C. J., de Jong, W., Galloway, G., Pacheco, P., and Winkel, G. (eds) Sustainable Development Goals: Their Impacts on Forests and People. Cambridge: Cambridge University Press, pp. 146–177. https://doi.org/10.1017/9781108765015

163 Larson, A. M., Dokken, T., Duchelle, A. E., Atmadja, S., Resosudarmo, I. A. P., Cronkleton, P., ... & Selaya, G., 2015. The role of women in early REDD+ implementation: lessons for future engagement. International Forestry Review, 17(1), 43-65. http://www.jstor.org/stable/24310651

164 Larson, A. M., Solis, D., Duchelle, A. E., Atmadja, S., Resosudarmo, I. A. P., Dokken, T., & Komalasari, M., 2018. Gender lessons for climate initiatives: A comparative study of REDD+ impacts on subjective wellbeing. World Development, 108, 86-102. https://doi.org/10.1016/j.worlddev.2018.02.027

165 Basnett, B. S., Elias, M., Ihalainen, M., & Valencia, A. M. P., 2017. Gender Matters in Forest Landscape Restoration: a framework for design and evaluation. CIFOR: Bogor, Indonesia. https://www.cifor.org/knowledge/publication/6685/

166 International Union for Conservation of Nature, 2017. Gender-responsive restoration guidelines. A closer look at gender in the Restoration Opportunities Assessment Methodology. IUCN, Gland, 25 pp. https://portals.iucn.org/library/node/46693

167 UN Women, Global Mechanism of the UNCCD, and IUCN, 2019. A manual for gender-responsive land degradation neutrality transformative projects and programmes. Global Mechanism of the UNCCD and UN Women, pp.1-60. https://www.unwomen.org/en/digital-library/publications/2019/09/manual-for-gender-responsive-land-degradation-neutrality-transformative-projects-and-programmes

168 TREEAID, 2020. Strengthening Forest Management to Protect Biodiversity and Alleviate Poverty in Mali, West Africa. Tree Aid learning Brief (July 2020). https://www.treeaid.org/media/1ivjzndb/tree-aid-strengthening-forest-management-learning-brief-2020-english.pdf

169 Naughton, C.C., Deubel, T.F. and Mihelcic, J.R., 2017. Household food security, economic empowerment, and the social capital of women's shea butter production in Mali. Food Security, 9(4), pp.773-784. https://doi.org/10.1007/s12571-017-0706-y

170 International Land Coalition and Trocaire, 2021. Securing women's land rights in Nicaragua. ILC. https://learn.landcoalition.org/en/good-practices/securing-womens-land-rights-in-nicaragua

171 Mwangi, E., and Evans, M., 2018. Shaking the tree: Challenging gender, tenure and leadership norms through collaborative reforestation in Central Uganda. Story 12. In: Mwangi E.and Evans M., Communities restoring landscapes: Stories of resilience and success. Center for International Forestry Research (CIFOR), Global Landscapes Forum. https://doi.org/10.17528/cifor/006980

172 Mukasa C., and Tibazalika A., 2018. Enhancing Women's Participation in Forestry Management Using Adaptive Collaborative Management. The Case of Mbazzi Farmers Association, Mpigi District Uganda. Lessons for gender-responsive landscape restoration, GLF Brief 6 pp4. CIFOR, Global Landscapes Forum https://www.globallandscapesforum.org/publication/enhancing-womens-participation-in-forestry-management-using-adaptive-collaborative-management-the-case-of-mbazzi-farmers-association-mpigi-district-uganda

173 FAO and CARE, 2019. Good Practices for Integrating Gender Equality and Women's Empowerment in Climate-Smart Agriculture Programmes. FAO, Atlanta, p.108. https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1195137

174 Salcedo-La Viña, C. and Giovarelli, R., 2021. On Equal Ground: Promising Practices for Realizing Women's Rights in Collectively Held Lands. World Resources Institute, pp.108. https://www.doi.org/10.46830/wrirpt.19.00007

175 Center for International Forestry Research, 2015. Gender integration in the Nyimba Forest project, Zambia (03 March) https://www2.cifor.org/gender/gender-integration-nyimba-forest-project-zambia

176 Donald, A., Goldstein, M., Hartman, A., La Ferrara, E., O'Sullivan, M., and Stickler, M., 2020. What's Mine is Yours: Pilot Evidence from a Randomized Impact Evaluation on Property Rights and Women's Empowerment in Cote d'Ivoire. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/34081

177 HLPE, 2021. Promoting youth engagement and employment in agriculture and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome. https://www.fao.org/3/cb5464en/cb5464en.pdf

178 The Grenada Goat Diary Project, (n.d.). Project Background. https://www.thegoatdairy.org/project-background

179 Aidan N., 2016. Profile: Independent Documentary – Grenada and the Goats. INDIE FARMER (27 February) https://www.indiefarmer.com/2016/02/27/independent-documentary-grenada-and-the-goats/

180 The Grenada Goat Diary Project, (n.d.) Facebook official profile. https://www.facebook.com/thegoatdairy

181 The Grenada Goat Diary Project, (n.d.) St. Patrick's Anglican Public School. https://www.thegoatdairy.org/st-patricks-anglican-public-school

182 Trading Economics, 2022. Morocco Youth Unemployment Rate (Data source Haut Commissariat au Plan, Morocco). https://tradingeconomics.com/morocco/youth-unemployment-rate

183 Deutsche Gesellschaft für Internationale Zusammenarbeit, 2020. What works in rural youth employment promotion? Good practices and lessons from GIZ Programmes on rural youth employment. Germany, GIZ, pp.1–108. https://www.giz.de/en/downloads/giz2020_eng_employment_promotion.pdf?deliveryName=DM82716

184 Sustainable Development Goals Fund, 2019. Case study. Nigeria: Food Africa – Empowering Youth and Promoting Innovative Public-Private Partnerships through More Efficient Agro-Food Value Chains in Nigeria. SDG Fund. https://www.sdgfund.org/case-study/nigeria-food-africa-%E2%80%93-empowering-youth-and-promoting-innovative-public-private

185 Sustainable Development Goals Fund, 2017. Food Africa – Empowering Youth and Promoting Innovative Public-Private Partnerships through More Efficient Agro-Food Value Chains in Nigeria. Nigeria JP with private sector proposals. https://www.sdgfund.org/sites/default/files/nigeria_sdg_fund_-_jp_with_private_sector_document.pdf

186 UNDP Goodwill Ambassadors, (n.d.) The Roca Brothers. https://www.undp.org/goodwill-ambassadors/Roca-brothers

187 Deutsche Gesellschaft für Internationale Zusammenarbeit, 2020. What works in rural youth employment promotion? Good practices and lessons from GIZ Programmes on rural youth employment. Germany, GIZ, pp.1–108. https://www.giz.de/en/downloads/giz2020_eng_employment_promotion.pdf?deliveryName=DM82716

188 O'Neill, A., 2022. Samoa - youth unemployment rate 1999-2019. STATISTA (01 February) https://www.statista.com/statistics/812943/youth-unemployment-rate-in-samoa

189 UNDP Multi-Country Office covering the Cook Islands, Nue, Samoa and Tokelau, 2018. Samoa: Evaluation of the SDGs trust fund "Farm to Table" Project with Women in Development Incorporated (WIBDI). Final report (July). UNDP https://www.sdgfund.org/sites/default/files/samoa_sdg_fund_final_evaluation_report.pdf

190 Gove, E., 2016. Local Flavors: A Look at Farm to Table in Samoa. Independent Study Project (ISP) Collection. 2385. https://digitalcollections.sit.edu/isp_collection/2385

191 United Nations Development Group and UNDP, 2018. MPTF Office generic final programme narrative Report. Reporting period: from April 2016 to December 2018. Engaging Youth in Samoa in Organic Farming and Menus: A Farm to Table Value Chain Approach. https://www.sdgfund.org/sites/default/files/samoa_sdg_fund_final_narrative_report_0.pdf

192 "Farm to Table" App, (n.d.) Google Play. https://play.google.com/store/apps/details?id=com.farm.totable

193 United Nations Development Group and UNDP, 2018. MPTF Office generic final programme narrative Report. Reporting period: from April 2016 to December 2018. Engaging Youth in Samoa in Organic Farming and Menus: A Farm to Table Value Chain Approach. https://www.sdgfund.org/sites/default/files/samoa_sdg_fund_final_narrative_report_0.pdf

194 Sustainable Development Goals Fund, UNDP, and IFAD, 2019. Case Study. Samoa: Engaging Youth in Samoa in Organic Farming and Menus: A Farm to Table Value Chain Approach. Sustainable Development Goals Fund. https://www.sdgfund.org/case-study/samoa-engaging-youth-samoa-organic-farming-and-menus-farm-table-value-chain-approach

195 SAKALA Cité Soleil's Youth Community Center, 2019. Cité Soleil. Haiti, SAKALA. https://www.sakala-haiti.org/cite-soleil

196 Halliday, J., 2018. The Garden that Turned a "Red" Zone Green. In Urban Agriculture Magazine No. 35, Youth in Food, Opportunities for education and employment. RUAF (November) pp.19–20. https://ruaf.org/document/urban-agriculture-magazine-no-35-youth-in-food-opportunities-for-education-and-employment

197 SAKALA Cité Soleil's Youth Community Center, 2019. Agronomy at SAKALA. Haiti, SAKALA https://www.sakala-haiti.org/agronomy

198 Minority Rights Group International, 2017. No escape from discrimination: minorities, indigenous peoples and the crisis of displacement, REPORT. MRG https://reliefweb.int/report/world/no-escape-discrimination-minorities-indigenous-peoples-and-crisis-displacement

199 United Nations General Assembly, 2007. United Nations Declaration on the Rights of Indigenous People. https://undocs.org/A/RES/61/295

200 David Suzuki Foundation, 2022. What is Land Back? https://davidsuzuki.org/what-you-can-do/what-is-land-back

201 Pieratos, N.A., Manning, S.S. and Tilsen, N., 2020. Land Back: A meta narrative to help indigenous people show up as movement leaders. Leadership, 17(1), pp.47-61. https://doi.org/10.1177/1742715020976204

202 Gamblin R., (n.d.) LAND BACK! What do we mean? 4Rs Youth Movement, https://4rsyouth.ca/land-back-what-do-we-mean

203 Braganza C., 2018. How to transfer your land to Indigenous Peoples, TVO (28 June) https://www.tvo.org/article/how-to-transfer-your-land-to-indigenous-peoples

204 Native Governance Center, 2021. Voluntary Land Taxes. (09 March) https://nativegov.org/voluntary-land-taxes

205 Robbins J., 2021. How Returning Lands to Native Tribes is Helping Protect Nature. Yale Environment360 (3 June) https://e360.yale.edu/features/how-returning-lands-to-native-tribes-is-helping-protect-nature

206 Queensland Government, 2021. 160,000 hectares returned on path to reconciliation. Joint Statement. Minister for Seniors and Disability Services and Minister for Aboriginal and Torres Strait Islander Partnerships the Honourable Craig Crawford, Minister for the Environment and the Great Barrier Reef and Minister for Science and Youth Affairs the Honourable Meaghan Scanlon (29 September) https://statements.qld.gov.au/statements/93360

207 Australian Conservation Foundation, 2021. Historic handback as Queensland returns world heritage Daintree to First Nations ownership (29 September) https://www.acf.org.au/queensland-returns-daintree-to-first-nations-ownership

208 Anderson T.L., 2020. The case for transferring federal lands back to Native Americans. The Hill (06 March) https://thehill.com/opinion/civil-rights/486177-the-case-for-transferring-federal-lands-back-to-native-americans

209 Robbins J., 2021. How Returning Lands to Native Tribes is Helping Protect Nature. Yale Environment360 (3 June) https://e360.yale.edu/features/how-returning-lands-to-native-tribes-is-helping-protect-nature

210 Yellowhead Institute, 2019. Land Back, a Yellowhead Institute Red Paper. Toronto, Yellowhead Institute https://redpaper.yellowheadinstitute.org/wp-content/uploads/2019/10/red-paper-report-final.pdf

211 UNHCR, 2021. Figures at a Glance. 82.4 million people worldwide were forcibly displaced. https://www.unhcr.org/en-us/figures-at-a-glance.html

212 Internal Displacement Monitoring Centre, 2021. Global Report on Internal Displacement 2021 (GRID 2021): internal displacement in a changing climate, IDMC. https://www.internal-displacement.org/global-report/grid2021

213 Katz, E., 2010. Land tenure, property rights, and natural resource management: land tenure and property rights reform in the developing world: who is vulnerable. Prepared for the United States Agency for International Development, USAID Contract Number EPP-00-06-00008-00, Property Rights and Resource Governance (PRRGP) Task Order. https://land-links.org/wp-content/uploads/2016/09/USAID_Land_Tenure_Vulnerable_Populations_Report.pdf

214 Banbury T, Beyrer C, and Spiegel P., 2020. Covid-19 and the displaced: addressing the threat of the novel coronavirus in humanitarian emergencies. Refugees International. https://www.refugeesinternational.org/reports/2020/3/29/covid-19-and-the-displaced-addressing-the-threat-of-the-novel-coronavirus-in-humanitarian-emergencies

215 UNHCR, 2021. Uganda – Refugee Statistics Map - August 2021. Operational Data Portal (ODP) Refugee Situations https://data2.unhcr.org/en/documents/details/88501

216 Betts, A., Chaara, I., Omata, N., and Sterck, O., 2019. Refugee Economies in Uganda: What Difference Does the Self-Reliance Model Make? Oxford, Refugee Studies Centre (RSC) & University of Oxford https://www.rsc.ox.ac.uk/publications/refugee-economies-in-uganda-what-difference-does-the-self-reliance-model-make

217 Bohnet, H., and Schmitz-Pranghe, C., 2019. Uganda: a role model for refugee integration? Bonn International Center for Conflict Studies Working Paper, 2/2019. Bonn. https://www.ssoar.info/ssoar/handle/document/62871

218 Idris, I., 2020. Integrated approaches to refugee management in Uganda. Helpdesk Report 716. Brighton, UK: Institute of Development Studies. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/14991

219 Ministry of Gender, Labour and Social Development of the Republic Uganda, 2020. Jobs and Livelihoods Integrated Response Plan for Refugees and Host Communities in Uganda 2020-2021 -2024-2025. https://data2.unhcr.org/en/documents/details/86601

220 UNHCR, 2021. Uganda - Refugee Settlement Statistics July 2021 - Bidibidi. UNHCR Operational Data Portal (ODP) Refugee Situations. https://data2.unhcr.org/en/documents/details/88097

221 Wernick A., 2019. In Uganda, a refugee camp becomes a city. The World (09 May) https://theworld.org/stories/2019-05-09/uganda-refugee-camp-becomes-city

222 Krug T., 2019. South Sudanese Refugees transform a camp into a city in Uganda. VOA News (07 September) https://www.voanews.com/africa/south-sudanese-refugees-transform-camp-city-uganda

223 De Raaij M. 2021, Refugees and Restoration, Ecosystem Resilience Camps (07 September) https://www.resilience.org/stories/2021-09-07/refugees-and-restoration

224 YICE, 2021. Empowering People: Youth Initiative for Community Empowerment (YICE) https://yiceug.org

225 Idris, I., 2020. Integrated approaches to refugee management in Uganda. Helpdesk Report 716. Brighton, UK: Institute of Development Studies https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/14991

226 Lush Spring Prize, 2021. Lush Spring Prize for social and environmental regeneration: YICE Uganda https://springprize.org/shortlisted/yice-uganda

227 Re-alliance, 2021. Kitchen gardens, composting and organic farming in Uganda refugee settlement https://www.re-alliance.org/ugandan-refugee-kitchen-gardens

228 B. Bendandi. 2020. Migration induced by climate change and environmental degradation in the Central Mediterranean Route, in IOM. 2020. Migration in West and North Africa and Across the Mediterranean: Trends, Risks, Development and Governance, pp.496. https://publications.iom.int/system/files/pdf/ch26-migration-induced-by-climate-change.pdf

229 Sustainability, Stability and Security in Africa, 2022. 3S Initiative Home page. https://3s-initiative.org/en/home

230 Chiriac M., and Veger M., 2019. Returning Migrants receive agricultural training in Agadez, Niger. UNCCD (13 March). https://www.unccd.int/news-events/returning-migrants-receive-agricultural-training-agadez-niger

231 ACAPS, 2021. Bangladesh, Rohingya Refugees. https://www.acaps.org/country/bangladesh/crisis/rohingya-refugees

232 Hassan, M, Smith, A., Walker, K., Rahman, M. and Southworth, J., 2018. Rohingya Refugee Crisis and Forest Cover Change in Teknaf, Bangladesh. Remote Sensing, 10(5), 689. https://doi.org/10.3390/rs10050689

233 Babu, K. and Scott M., 2020. The impacts and challenges to host country Bangladesh due to sheltering the Rohingya refugees. Cogent Social Sciences, 6(1), p.1770943. https://doi.org/10.1080/23311886.2020.1770943

234 FAO, 2020. Bangladesh: FAO and Rohingya refugees restore forests in and around once barren camps. FAO Stories. (22 October) http://www.fao.org/emergencies/fao-in-action/stories/stories-detail/en/c/1317268

235 Villena V.H. and Gioia D.A., 2020. A more sustainable supply chain: Companies tend to focus on their top-tier suppliers, but the real risks come lower down. Harvard Business Review (March-April), 1-11. https://hbr.org/2020/03/a-more-sustainable-supply-chain

236 Big Tree Farms, 2020. Rooted in Goodness. http://www.bigtreefarms.com

237 Business Call to Action, (n.d.) Big Tree Farms. https://www.businesscalltoaction.org/member/big-tree-farms

238 Canon T., 2018. Sustainable Farming in Bali: Ben Ripple of Big Tree Farms. Ethical Foods https://ethicalfoods.com/ben-ripple-big-tree-farms

239 Global Forest Watch, (n.d.) Dashboard - Côte d'Ivoire. https://bit.ly/3wrXW91

240 Global Forest Watch, (n.d.) Dashboard - Ghana. https://bit.ly/3EWXXoa

241 Nestle, Cocoa and Forest Initiative, 2019. Cocoa & Forests Initiative: Nestlé's Initial Action Plan to end deforestation and promote forest restoration and protection in the cocoa supply chain. Nestle. https://www.nestle.com/sites/default/files/asset-library/documents/library/documents/corporate_social_responsibility/cocoa-and-forests-initiative-nestle-initial-action-plan.pdf

242 Nestle, Cocoa and Forests Initiative, 2020. Tackling Deforestation. Progress Report 2020, p.18. https://www.nestlecocoaplan.com/themes/custom/cocoa/dist/assets/documents/Nestle_CFI_Tackling_Deforestation_Progress_Report_2020.pdf

243 AVSF Sustainable Cashmere Programme, 2020. AVSF Sustainable cashmere programme Mongolia. SwitchAsia, Ulaanbaatar https://www.switch-asia.eu/resource/avsf-sustainable-cashmere-programme

244 Sustainable Cashmere Platform, UNDP, 2020. Why sustainable cashmere? http://sustainablecashmereplatform.com/

245 AVSF, (n.d.) Sustainable cashmere-fiber supply chain in Mongolia https://www.avsf.org/en/posts/2149/full/Sustainable_cashmere-fiber_supply_chain_in_Mongolia

246 Parodi, G., 2018. Agroecological transition and reconfiguration of horticultural work among family farmers in Buenos Aires, Argentina. Cahiers Agricultures, 27(3), p.35003. https://doi.org/10.1051/cagri/2018020

247 Relmucao, J.J., 2021. The Union of Land Workers is Creating a New Food Paradigm in Argentina. NACLA (06 April) https://nacla.org/news/2021/04/06/land-workers-argentina-food-sovereignty

248 Booth, A., 2020. Argentina's big squeeze. New Internationalist (22 April) https://newint.org/features/2020/02/10/argentina-big-squeeze

249 New Internationalist. 2020. 9 inspiring food-aid projects. New Internationalist (17 November) https://newint.org/features/2020/11/17/9-inspiring-food-aid-projects

250 Parodi, G., 2018. Agroecological transition and reconfiguration of horticultural work among family farmers in Buenos Aires, Argentina. Cahiers Agricultures, 27(3), p.35003. https://doi.org/10.1051/cagri/2018020

251 Unión de Trabajadores de la Tierra, 2020. Certificaciones agroecológicas: sin veneno y con justicia social. https://uniondetrabajadoresdelatierra.com.ar/2020/07/03/certificaciones-agroecologicas-sin-veneno-y-con-justicia-social

252 Mahar A., 2021. Meet the farmers helping to reforest Timor-Leste. World Economic Forum (26 January) https://www.weforum.org/agenda/2021/01/how-farmers-help-to-reforest-timor-leste-withoneseed

253 AlVelAl Association, (n.d.). Initiative de 4 retornos. https://alvelal.wixsite.com/website-6

254 AlVelAl Foods, 2021. Comprar Productos Ecológicos - Agricultura Regenerativa. https://alvelalfoods.org

255 Renature, 2020. Creating the 'new normal' with palm oil agroforestry. Renature (16 November). https://www.renature.co/articles/palm-oil-agroforestry

256 Rizzuti, A., 2020. Food Crime: A Review of the UK Institutional Perception of Illicit Practices in the Food Sector. Social Sciences, 9(7), 112. https://doi.org/10.3390/socsci9070112

257 Cao, D., 2020. Global risks of intensive animal farming and the wildlife trade. Animal Sentience, 5(30). https://doi.org/10.51291/2377-7478.1629

258 Goulson, D., 2020. Pesticides, Corporate Irresponsibility, and the Fate of Our Planet. One Earth, 2(4), pp.302–305. https://doi.org/10.1016/j.oneear.2020.03.004

259 Tsatsakis, A.M., Nawaz, M.A., Tutelyan, V.A., Golokhvast, K.S., Kalantzi, O.-I., Chung, D.H., Kang, S.J., Coleman, M.D., Tyshko, N., Yang, S.H. and Chung, G., 2017. Impact on environment, ecosystem, diversity and health from culturing and using GMOs as feed and food. Food and Chemical Toxicology, 107, pp.108–121. https://doi.org/10.1016/j.fct.2017.06.033

260 Anomaly, J., 2014. What's Wrong with Factory Farming? Public Health Ethics, 8(3), pp.246–254. https://doi.org/10.1093/phe/phu001

261 Baur, G., 2019. The end of factory farming: Changing hearts, minds, and the system. In Dhont, K., & Hodson, G. (Eds.). Why We Love and Exploit Animals: Bridging Insights from Academia and Advocacy (1st ed.). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9781351181440-14/end-factory-farming-gene-baur

262 Tadel K., 2021. Big Food in Africa: Endangering People's Health. Alliance for Food Sovereignty in Africa (AFSA) (21 September) https://afsafrica.org/big-food-in-africa-endangering-peoples-health

263 Mkindi, A., Maina, A., Urhahn, J.U., Koch, J., Goïta, M., Nketani, M., Herre, R., Tanzmann, S., Wise, T.A., Gordon, M. and Gilbert., R., 2020. False Promisses. The Alliance for a Green Revolution in Africa (AGRA). pp.1–42. https://www.rosalux.de/en/publication/id/42635/false-promises-the-alliance-for-a-green-revolution-in-africa-agra

264 Alonso-Fradejas, A., Forero, L. F., Ortega-Espès, D., Drago, M., and Chandrasekaran, K. 2020. 'Junk Agroecology': The corporate capture of agroecology for a partial ecological transition without social justice. Friends of the Earth International, Transnational Institute, and Crocevia. https://www.tni.org/files/publication-downloads/38_foei_junk_agroecology_full_report_eng_lr_0.pdf

265 Wise, T. A., 2021. Old Fertilizer in New Bottles: Selling the Past as Innovation in Africa's Green Revolution. Global Development and Environment Institute, Working Paper No21.01, Medford USA, Tufts University. https://mronline.org/wp-content/uploads/2021/04/21-01Wise_OldFertilizer.pdf

266 Lentera Africa, 2020. Welcome to Lentera Africa. https://lenterafrica.com

267 Anderson, W., 2019. Attention Investors: African Entrepreneurs Are Restoring Land and Making Profit. World Resources Institute (25 October) https://www.wri.org/insights/attention-investors-african-entrepreneurs-are-restoring-land-and-making-profit

268 Agro-Eco Services, 2021. Homepage - Agroeco services. Benin. https://www.agroecoservices.com

269 Simpson, T., 2021. Land Accelerator Africa: Dozens of Restoration Entrepreneurs, One Mission. World Resources Institute (02 September) https://www.wri.org/update/land-accelerator-africa-dozens-restoration-entrepreneurs-one-mission

270 CADEL Business, 2020. Cadel Business Consulting Homepage. Burkina Faso. https://www.cadelafrica.com

271 Simpson, T., 2021. Land Accelerator Africa: Dozens of Restoration Entrepreneurs, One Mission. World Resources Institute (02 September) https://www.wri.org/update/land-accelerator-africa-dozens-restoration-entrepreneurs-one-mission

272 RECYCL'AFRICA, 2021. RECYCL'AFRICA Homepage, Rwanda. https://recyclafrica.com/zyx.html

273 Nature's Nectar, (n.d.) Zambia's most sustainable & impactful honey. https://www.naturesnectarzambia.com

274 Simpson, T., 2021. Land Accelerator Africa: Dozens of Restoration Entrepreneurs, One Mission. World Resources Institute (02 September) https://www.wri.org/update/land-accelerator-africa-dozens-restoration-entrepreneurs-one-mission

275 Agriworks Uganda, 2021. AGRIWORKS UGANDA Homepage, Irrigation Services for Smallholders. https://www.agriworksug.com

276 Simpson, T., 2021. Land Accelerator Africa: Dozens of Restoration Entrepreneurs, One Mission. World Resources Institute (02 September) https://www.wri.org/update/land-accelerator-africa-dozens-restoration-entrepreneurs-one-mission

277 Ng'wala Inventions, 2021. Ng'wala inventions Homepage. https://www.ngwalainventions.co.tz

278 Simpson, T., 2021. Land Accelerator Africa: Dozens of Restoration Entrepreneurs, One Mission. World Resources Institute (02 September) https://www.wri.org/update/land-accelerator-africa-dozens-restoration-entrepreneurs-one-mission

279 Tilaa Ltd, (n.d.) Tilaa Ltd - About. https://tilaaltd.com/about

280 Iyer, V., Gronkiewicz, M., Kabiru, S., Anderson, W. and Gant, A., 2021. Entrepreneurs Need Funding to Restore Africa's Degraded Land. World Resources Institute (04 October) https://www.wri.org/insights/financing-entrepreneurs-reverse-land-degradation

281 Plug'n'Grow, 2019. Plug'n'Grow Homepage. Cairo. https://www.plugngrow.me

282 Desert Control, (n.d.) Desert Control Homepage: Making Earth Green Again. https://www.desertcontrol.com

283 St. Jude's Herbals, 2021. Plantopathy. https://stjudesindia.in/plantopathy

284 Rhodotion, (n.d.) Rhodotion Homepage. https://www.rhodotion.com

285 World Resources Institute India and Sangam Ventures, 2020. Land Accelerator 15 entrepreneurs pitch businesses that restore farms and forests before investors. WRI India (01 December). https://wri-india.org/events/land-accelerator-south-asia-cohort-2020

286 SenzAgro, 2021. SanzAgro Homepage: Smart Irrigation system with advance sensing technology. https://senzagro.com

287 World Resources Institute India and Sangam Ventures, 2020. Land Accelerator 15 entrepreneurs pitch businesses that restore farms and forests before investors. WRI India (01 December). https://wri-india.org/events/land-accelerator-south-asia-cohort-2020

288 Village Link Company Limited, 2021. Homepage Village Link Company Limited. https://www.villagelink.co

289 Ho, S., 2020. These 9 Sustainable Startups Are Fixing Our Food Systems. Green Queen (11 December) https://www.greenqueen.com.hk/sustainable-food-startups

290 HEVEA Costa Rica, 2021. Hevea Costa Rica Desarrollos Agroforestales S.A. Homepage. https://www.heveacr.com/en

291 World Resources Institute, 2021. The Land Accelerator - Our Companies. https://www.wri.org/initiatives/land-accelerator/our-companies

292 Prontal, 2021. Prontal Homepage – Reforesting in the face of climate change. https://eng.prontal.com.mx

293 Initiative 20x20 Secretariat, 2021. Meet 15 Entrepreneurs Restoring Latin America's Farms and Forests (05 January). https://initiative20x20.org/es/node/533

294 Relicto, 2021. Relicto - Propagando bosque nativo. https://relicto.cl

295 Cheng, B., 2021. Land Restoration Businesses Are Key to Latin America's Economic Recovery. Initiative 20x20 (17 May) https://initiative20x20.org/news/land-restoration-businesses-latin-america-economic-recovery

296 Nicaforest, (n.d.) Nicaforest Homepage. https://www.nicaforest.com

297 Initiative 20x20 Secretariat, 2021. Land Accelerator Latin America Demo Days. https://initiative20x20.org/events/land-accelerator-latin-america-demo-days

298 Adapta Group, 2018. Adapta Group Home page. https://adaptagroup.com/home

299 Revofarm, 2021. Revofarm - Revolutionizing agriculture with data. https://revofarm.com

300 Jamaica Observer, 2015. Start-Up Jamaica alum, Revofarm, pitches app in Peru. Jamaica Observer (10 January) https://www.jamaicaobserver.com/business/Start-Up-Jamaica-alum--Revofarm--pitches-app-in-Peru-_18202156

301 Dendra Systems, 2021. Dendra Systems Homepage. https://dendra.io

302 UKTN, 2021. How Oxford-based Dendra Systems is using AI and drones to combat deforestation? UKTech (11 February) https://www.uktech.news/news/oxford-dendra-systems-uses-ai-drones-to-combat-deforestation-20210211

303 Terramera, 2019. Terramera Inc Homepage. https://www.terramera.com/

304 Terramera, 2019. ActigateTM Technology. https://www.terramera.com/actigate-technology

305 Terramera, 2019. Terramera Inc About Us. https://www.terramera.com/company/about-us

306 Mootral, 2021. Mootral Homepage. https://mootral.com

307 Chittose Group, (n.d.) Business Entities: Tierraponica, Inc. https://chitose-bio.com/business/tierraponica

308 Rethink Events, 2020. Meet the Asia-Pacific innovators shaking up the agri-food system. Eco-Business (21 October) https://www.eco-business.com/press-releases/meet-the-asia-pacific-innovators-shaking-up-the-agri-food-system

309 Guerra, C.A., Rosa, I.M.D., and Pereira, H.M., 2019. Change versus stability: are protected areas particularly pressured by land cover change? Landscape Ecology, 34, 2779-2790. https://doi.org/10.1007/s10980-019-00918-4

310 Keenelyside, K., Dudley, N., Cairns, S., Hall, C. and Stolton, S., 2012. Ecological restoration for protected areas: principles, guidelines and best practices (Vol. 18). IUCN, Gland. https://www.iucn.org/content/ecological-restoration-protected-areas-principles-guidelines-and-best-practices

311 Donald, P.F., Balmford, A., Couturier, A.R., Gacheru, P., Jathar, G.A., Marnewick, D., Reaney, L., Skiyarenko, S., Butchart, S.H.M., Buchanan, G.M., Bingham, H., De La, G.E., Herzog, S.K., Kingston, N., Maurer, G., Shmygaieva, T., and Stevens, C.M.D., 2019. The prevalence, characteristics and effectiveness of Aichi Target 11's "other effective area-based conservation measures" (OECMs) in Key Biodiversity Areas between unprotected KBAs with or without OECMs in forest loss or in a number of state-pressure-response metrics. Conservation Letters, 12(5), 212659. https://doi.org/10.1111/conl.12659

312 Convention on Biological Diversity (n.d.) Aichi target 11. https://www.cbd.int/aichi-targets/target/11

313 Convention on Biological Diversity Secretariat, 2020. Global Biodiversity Outlook 5, Montreal. https://www.cbd.int/gbo5

314 Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A. and Dubois, G., 2019. Global trends in protected area connectivity from 2010 to 2018. Biological Conservation, 238, pp.1-8. https://doi.org/10.1016/j.biocon.2019.07.028

315 Hannah, L., Roehrdanz, P.R., Marquet, P.A., Enquist, B.J., Midgley, G., Foden, W., Lovett, J.C., Corlett, R.T., Corcoran, D., Butchart, S.H. and Boyle, B., 2020. 30% land conservation and climate action reduces tropical extinction risk by more than 50%. Ecography, 43(7), pp.943-953. https://doi.org/10.1111/ecog.05166

316 Dinerstein, E., Olson, D., Joshi, A., Vynne, C., Burgess, N.D., Wikramanayake, E., Hahn, N., Palminteri, S., Hedao, P., Noss, R., Hansen, M., Locke, H., Ellis, E.C., Jones, B., Barber, C.V., Hayes, R., Kormos, C., Martin, V., Crist, E., Sechrest, W., Price, L., Baillie, J.E.M., Weeden, D., Suckling, K., Davis, C. Sizer, N., Moore, R., Thau, D., Birch, T., Potapov, P., Turubanova, S., Tyukavina, A., de Souza, N., Pintea, L., Brito, J.C., Llewellyn, O.A., Miller, A.G., Patzelt, A., Ghazanfar, S.A. Timberlake, J., Kloser, H., Shennan-Farpon, Y., Kindt, R., Barnekow Lilleso, J-P., van Breugel, P., Graudal, L., Voge, M., Al-Shammari, K.F., and Saleem, M., 2017. An ecoregion-based approach to protecting half the terrestrial realm. BioScience, 67(6): pp.534-545. https://doi.org/10.1093/biosci/bix014

317 Convention on Biological Diversity, 2018. Decision adopted by the Conference of the Parties to the Convention on Biological Diversity 14/8. Protected areas and other effective area-based conservation measures (CBD/COP/DEC/14/8). https://www.cbd.int/decision/cop/?id=13650

318 Geldmann, J., Coad, L., Barnes, M.D., Craigie, I.D., Woodley, S., Balmford, A., Brooks, T.M., Hockings, M., Knights, K., Mascia, M.B., McRae, L. and Burgess, N.D., 2018. A global analysis of management capacity and ecological outcomes in terrestrial protected areas. Conservation Letters, 11(3), e12434. https://doi.org/10.1111/conl.12434

319 Borrini-Feyerabend, G., N. Dudley, T. Jaeger, B. Lassen, N. Pathak Broome, A. Phillips and T. Sandwith, 2013. Governance of Protected Areas: From understanding to action. Best Practice Protected Area Guidelines Series No. 20. IUCN, Gland. https://www.iucn.org/content/governance-protected-areas-understanding-action-0

320 Brandt, J.S., Allendorf, T., Radeloff, V., and Brooks, J., 2017. Effects of national forest-management regimes on unprotected forests of the Himalaya. Conservation Biology, 31(6). https://doi.org/10.1111/cobi.12927

321 Eghenter, C., 2018. Indigenous effective area-based conservation measures: conservation practices among the Dayak Kenyah of North Kalimantan. Parks, 24 Special Issue, June 2018. https://parksjournal.com/wp-content/uploads/2020/10/PARKS-24-SI-Eghenter-10.2305-IUCN.CH_.2018.PARKS%E2%80%9024%E2%80%90SICE.en_.pdf

322 Convention on Biological Diversity Secretariat, 2020. Global Biodiversity Outlook 5, Montreal. https://www.cbd.int/gbo5

323 Furumo, P.R. and Lambin, E.F., 2020. Scaling up zero-deforestation initiatives through public-private partnerships: A look inside post-conflict Colombia. Global Environmental Change, 62, 102055. https://doi.org/10.1016/j.gloenvcha.2020.102055

324 African Parks, 2020. A charted course. African parks annual report 2020. African parks, p.71. https://www.africanparks.org/2020-annual-report

325 African Parks, 2021. African Parks Homepage. https://www.africanparks.org

326 African Parks, 2020. A charted course. African parks annual report 2020. African parks, p.71. https://www.africanparks.org/2020-annual-report

327 Waithaka, J. and Wanyonyi, E., 2015. Park agencies collaborate to comprehensively tackle climate change impacts. In: D. Herr and Fischborn, M.,eds., African solutions in a rapidly changing world: nature-based solutions to climate change by African innovators in protected areas. IUCN, Gland, p.36. https://portals.iucn.org/library/sites/library/files/documents/2015-032.pdf

328 Waithaka, J., 2015. Park agencies collaborate to comprehensively tackle climate change impacts. Panorama Solutions (21 October) https://panorama.solutions/en/solution/park-agencies-collaborate-comprehensively-tackle-climate-change-impacts

329 Furumo, P.R. and Lambin, E.F., 2020. Scaling up zero-deforestation initiatives through public-private partnerships: A look inside post-conflict Colombia. Global Environmental Change, 62, 102055. https://doi.org/10.1016/j.gloenvcha.2020.102055

330 Altawalbeh, O., 2021. Ajloun Forest Reserve Is A leading model for Conservation of Nature and Developing the local community. Panorama solutions (07 October) https://panorama.solutions/en/solution/ajloun-forest-reserve-leading-model-conservation-nature-and-developing-local-community

331 Muamba, G., 2016. Transboundary collaboration in a conflict and post-conflict context. In: Clamote Rodrigues, D. and Fischborn, M., eds., Solutions in Focus: Transboundary Protected Area Solutions. IUCN, Gland, p.34. https://portals.iucn.org/library/sites/library/files/documents/2016-081.pdf

332 Herrera R., and Uribe, J., 2016. Transboundary conservation in the Selva Maya through park ranger exchanges. In: Clamote Rodrigues, D. and Fischborn, M., eds., Solutions in Focus: Transboundary Protected Area Solutions. IUCN, Gland, p.34. https://portals.iucn.org/library/sites/library/files/documents/2016-081.pdf

333 Selva Maya, 2020. Managers Of Protected Areas Of The Selva Maya Join Forces To Protect This Forest Massif (29 September). https://selvamaya.info/en/managers-of-protected-areas-of-the-selva-maya-join-forces-to-protect-this-forest-massif

334 CMS, 2020. Resolution 12.26 (Rev.COP13) on Improving Ways of Addressing Connectivity in the Conservation of Migratory Species https://www.cms.int/en/document/improving-ways-addressing-connectivity-conservation-migratory-species-4

335 Taylor, P. D., Fahrig, L., Henein, K., and Merriam, G., 1993. Connectivity Is a Vital Element of Landscape Structure. Oikos, 68, 571-572. https://doi.org/10.2307/3544927

336 Ward, M., Saura, S., Williams, B., Ramírez-Delgado, J.P., Arafeh-Dalmau, N., Allan, J.R., Venter, O., Dubois, G. and Watson, J.E., 2020. Just ten percent of the global terrestrial protected area network is structurally connected via intact land. Nature communications, 11(1), pp.1-10. https://doi.org/10.1038/s41467-020-18457-x

337 Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A. and Dubois, G., 2019. Global trends in protected area connectivity from 2010 to 2018. Biological Conservation, 238, p.108183. https://doi.org/10.1016/j.biocon.2019.07.028

338 Hilty, J., Worboys, G.L., Keeley, A., Woodley, S*, Lausche, B., Locke, H., Carr, M., Pulsford I., Pittock, J., White, J.W., Theobald, D.M., Levine, J., Reuling, M., Watson, J.E.M., Ament, R., and Tabor, G.M. 2020. Guidelines for conserving connectivity through ecological networks and corridors. Best Practice Protected Area Guidelines Series No. 30. Gland, Switzerland: IUCN. https://portals.iucn.org/library/sites/library/files/documents/PAG-030-En.pdf

339 Hilty, J., Worboys, G.L., Keeley, A., Woodley, S*, Lausche, B., Locke, H., Carr, M., Pulsford I., Pittock, J., White, J.W., Theobald, D.M., Levine, J., Reuling, M., Watson, J.E.M., Ament, R., and Tabor, G.M. 2020. Guidelines for conserving connectivity through ecological networks and corridors. Best Practice Protected Area Guidelines Series No. 30. Gland, Switzerland: IUCN. https://portals.iucn.org/library/sites/library/files/documents/PAG-030-En.pdf

340 Hilty, J., Worboys, G.L., Keeley, A., Woodley, S*, Lausche, B., Locke, H., Carr, M., Pulsford I., Pittock, J., White, J.W., Theobald, D.M., Levine, J., Reuling, M., Watson, J.E.M., Ament, R., and Tabor, G.M. 2020. Guidelines for conserving connectivity through ecological networks and corridors. Best Practice Protected Area Guidelines Series No. 30. Gland, Switzerland: IUCN. https://portals.iucn.org/library/sites/library/files/documents/PAG-030-En.pdf

341 Bernal Herrera F. et al., 2016. Technical Guidelines for the design and management of participatory connectivity conservation and restoration projects at the landscape scale in Latin America, Turrialba in 4Serie tecnica/ Boletin tecnico / CATIE; no.82, p. 44. https://repositorio.catie.ac.cr/handle/11554/8423?show=full

342 Hilty, J., Worboys, G.L., Keeley, A., Woodley, S*, Lausche, B., Locke, H., Carr, M., Pulsford I., Pittock, J., White, J.W., Theobald, D.M., Levine, J., Reuling, M., Watson, J.E.M., Ament, R., and Tabor, G.M., 2020. Guidelines for conserving connectivity through ecological networks and corridors. Best Practice Protected Area Guidelines Series No. 30. Gland, Switzerland: IUCN. https://portals.iucn.org/library/sites/library/files/documents/PAG-030-En.pdf

343 Society for Ecological Restoration, 2022. What is Ecological Restoration? https://www.ser-rrc.org/what-is-ecological-restoration

344 IUCN Commission on Ecosystem Management, 2020. Rewilding Principles. https://www.iucn.org/sites/dev/files/content/documents/principles_of_rewilding_cem_rtg.pdf

345 Carver, S, et al., 2021.Guiding principles for rewilding. Conservation Biology. 35:882–1893. https://doi.org/10.1002/cobi.13730

346 Tompkins Conservation, (n.d.) Tompkins Conservation Homepage. https://www.tompkinsconservation.org

347 Fundacion Rewilding Argentina, (n.d.) Ibera Project https://rewildingargentina.org/ibera-project

348 Lorimer, J., Sandom, C., Jepson, P., Doughty, C., Barua, M. and Kirby, K., 2015. Rewilding: Science, Practice, and Politics. Annual Review of Environment and Resources, 40(1), pp.39-62. https://doi.org/10.1146/annurev-environ-102014-021406

349 Perino, A., Pereira, H.M., Navarro, L.M., Fernández, N., Bullock, J.M., Ceaușu, S., Cortés-Avizanda, A., van Klink, R., Kuemmerle, T., Lomba, A. and Pe'er, G., 2019. Rewilding complex ecosystems. Science, 364(6438). https://doi.org/10.1126/science.aav5570

350 UNEP, 2019. Return of the jaguar. UNEP (04 January) https://www.unep.org/news-and-stories/story/return-jaguar

351 Pettersson, H. and Carvalho, S., 2020. Rewilding and gazetting the Iberá National Park: Using an asset approach to evaluate project success. Conservation Science and Practice, 3(5). https://doi.org/10.1111/csp2.258

352 Tompkins Conservation, 2020. Once-extinct Macaws are Repopulating Iberá. Tompkins Conservation News (30 June). https://www.tompkinsconservation.org/news/en/2020/06/30/once-extinct-macaws-are-repopulating-ibera/#more-1204

353 Volpe N.L., Thalinger B., Vilacoba E., Braukmann T.W.A, Di Giacomo A.S,. Berkunsky I., Lijtmaer D.A., Steinke D., and Kopuchian C., 2021. Diet composition of reintroduced Red-and-Green Macaws (Ara chloropterus) reflects gradual adaption to life in the wild. bioRxiv https://doi.org/10.1101/2021.04.14.439368

354 Fundacion Rewilding Chile, 2022. Patagonia National Park. https://www.rewildingchile.org/en/projects/patagonia-national-park

355 Bonnefoy P., 2018. With 10 Million Acres in Patagonia, a National Park System is Born. The New York Times (19 February) https://www.nytimes.com/2018/02/19/world/americas/patagonia-national-park-chile.html

356 Jones, P., and Comfort, D., 2020. A commentary on rewilding in Europe. Journal of Public Affairs, 20(3), e2071 https://doi.org/10.1002/pa.2071

357 European Parliament, 2020. Endangered Species in Europe: facts and figures, Infographic. European Parliament News (09 June) https://www.europarl.europa.eu/news/en/headlines/society/20200519STO79424/endangered-species-in-europe-facts-and-figures-infographic

358 Navarro, L. M., and Pereira, H. M., 2015. Rewilding abandoned landscapes in Europe. In Rewilding European Landscapes (pp. 3-23). Springer, Cham. https://doi.org/10.1007/978-3-319-12039-3_1

359 Rewilding Britain, 2022. Aurochs (Cow), Bos primigenius. https://www.rewildingbritain.org.uk/explore-rewilding/reintroductions-key-species/rewilding-superstars/aurochs-cow

360 The Royal Society for the Protection of Birds, (n.d.) Beaver reintroduction in the UK. https://www.rspb.org.uk/our-work/policy-insight/species/beaver-reintroduction-in-the-uk

361 BBC, 2019. Beavers to be reintroduced in Somerset and South Downs. BBC (20 November) https://www.bbc.com/news/uk-england-somerset-50485784

362 BBC, 2019. North York Moors beavers become parents. BBC (08 July) https://www.bbc.com/news/uk-england-york-north-yorkshire-48909027

363 BBC, 2020. Cumbria's Eden Valley to see reintroduction of beavers. (15 January) https://www.bbc.com/news/uk-england-cumbria-51111811

364 Devon Wildlife Trust, 2020. River Otter Beaver Trial. https://www.devonwildlifetrust.org/what-we-do/our-projects/river-otter-beaver-trial

365 Elliott, M., Blythe, C., Brazier, R.E., Burgess, P., King, S., Puttock, A., and Turner, C., 2017. Beavers – Nature's Water Engineers. A summary of initial findings from the Devon Beaver Projects. Devon Wildlife Trust. https://www.devonwildlifetrust.org/sites/default/files/2018-01/Beaver%20Project%20update%20%28LowRes%29%20.pdf

366 Brazier, R.E. Elliott, M., Andison, E., Auster, R.E., Bridgewater, S., Burgess, P., Chant, J., Graham, H., Knott, E., Puttock, A.K., Sansum, P., and Vowles, A., 2020. River Otter Beaver Trial Science and Evidence Report. Devon Wild Trust, pp.1–132. https://www.wildlifetrusts.org/sites/default/files/2020-05/River%20Otter%20Beaver%20Trial%20-%20Science%20and%20Evidence%20Report.pdf

367 Law, A., Gaywood, M.J., Jones, K.C., Ramsay, P. and Willby, N.J., 2017. Using ecosystem engineers as tools in habitat restoration and rewilding: beaver and wetlands. Science of The Total Environment, 605-606, pp.1021–1030. https://doi.org/10.1016/j.scitotenv.2017.06.173

368 IUCN, 2020. European bison recovering, 31 species declared extinct – IUCN Red List. IUCN News (10 December). https://www.iucn.org/news/species/202012/european-bison-recovering-31-species-declared-extinct-iucn-red-list

369 Rewilding Europe, (n.d.) European Rewilding Network: European bison in a Dutch dune system. https://rewildingeurope.com/rew-project/european-bison-in-a-dutch-dune-system

370 Boffey D., 2018. Return of the bison: herd makes surprising comeback on Dutch coast. The Guardian (28 May) https://www.theguardian.com/environment/2018/may/28/return-of-the-bison-herd-makes-surprising-comeback-on-dutch-coast

371 Life-Bison, 2016. Third bison release in the Southern Carpathians, Romania. Life Bison News (13 June) https://life-bison.com/news/third-bison-release-in-the-southern-carpathians-romania

372 Life-Bison, 2021. Unique European bison transport just arrived in the Southern Carpathians, Romania. Life Bison News (30 June) https://life-bison.com/news/new-bison-release-to-enhance-genetic-diversity-in-the-southern-carpathians-2

373 Kent Wildlife Trust, (n.d.) Wilder Blean. https://www.kentwildlifetrust.org.uk/wilderblean

374 Life-Bison, 2021. European Bison, the foodies of the wild. Life Bison News (28 January) https://life-bison.com/uncategorized/european-bison-the-foodies-of-the-wild

375 Rewilding Europe (n.d.) European Rewilding Network: European bison in a Dutch dune system. https://rewildingeurope.com/rew-project/european-bison-in-a-dutch-dune-system

376 Rewilding Europe, 2021. Griffon vulture population maintains upward trend in the Rhodope Mountains. Rewilding Europe News (08 June) https://rewildingeurope.com/news/griffon-vulture-population-maintains-upward-trend-in-the-rhodope-mountains

377 Phipps L., 2015. Vulture in crisis: poachers and poison threaten nature's garbage disposers. The Conversation (21 October) https://theconversation.com/vultures-in-crisis-poachers-and-poison-threaten-natures-garbage-disposers-49455

378 Rewilding Europe, 2021. LIFE RE-Vultures: Joint efforts successfully conserve vultures in the Eastern Rhodopes. Rewilding Europe News (24 June) https://rewilding-rhodopes.com/news/31894

379 Rewilding Europe, 2016. Poisoning hits wildlife in Eastern Rhodopes – Anti-poison dog units in action. Rewilding Europe News (24 October) https://rewildingeurope.com/news/poisoning-hits-wildlife-in-eastern-rhodopes-anti-poison-dog-units-in-action

380 Rewilding Europe, 2017. Electrocution caused the death of a rare black vulture. Rewilding Europe News (16 March) https://rewilding-rhodopes.com/life-vultures-news/electrocution-caused-the-death-of-a-rare-black-vulture

381 Vulture Conservation Foundation, 2021. LIFE RE-Vultures: Joint efforts successfully conserve vultures in the Eastern Rhodopes. https://4vultures.org/blog/life-re-vultures-joint-efforts-successfully-conserve-vultures-in-the-eastern-rhodopes

382 Cogan, K., 2021. Restoration ecology & rewilding in Europe: an overview of the case of the Marsican brown bear. https://www.researchgate.net/publication/350524548_RESTORATION_ECOLOGY_REWILDING_IN_EUROPE_AN_OVERVIEW_OF_THE_CASE_OF_THE_MARSICAN_BROWN_BEAR

383 McLellan, B.N., Proctor, M.F., Huber, D. and Michel, S., 2017. Ursus arctos (amended version of 2017 assessment). The IUCN Red List of Threatened Species 2017. Supplementary information. https://www.iucnredlist.org/species/41688/144339998#assessment-information

384 Rewilding Europe, (n.d.) Nature-based economies. https://rewilding-apennines.com/nature-based-economies

385 Usborne, S., 2020. How Abruzzo's wild bear population is making a comeback. National Geographic. (03 March) https://www.nationalgeographic.co.uk/travel/2020/03/how-abruzzos-wild-bear-population-making-comeback

386 Hoover, D.L., Bestelmeyer, B., Grimm, N.B., Huxman, T.E., Reed, S.C., Sala, O., Seastedt, T.R., Wilmer, H. and Ferrenberg, S., 2019. Traversing the Wasteland: A Framework for Assessing Ecological Threats to Drylands. BioScience 70(1), pp.35–47. https://doi.org/10.1093/biosci/biz126

387 Department of Forestry, Fisheries and the Environment, Republic of South Africa, (n.d.) Projects and programmes: Working for Ecosystems. https://www.environment.gov.za/projectsprogrammes/workingfor_ecosystems

388 Department of Environmental Affairs, Republic of South Africa. (n.d.) South Africa's Environmental Programmes: Supporting natural resource management through public employment programmes. https://www.dffe.gov.za/sites/default/files/docs/publications/nrm_booklet.pdf

389 Myers, N., Mittermeier, R.A., Mittermeier, C.G., Da Fonseca, G.A. and Kent, J., 2000. Biodiversity hotspots for conservation priorities, Nature 403:853-858. https://doi.org/10.1038/35002501

390 Bourne, A., Muller, H., de Villiers, A., Alam, M. and Hole, D., 2017. Assessing the efficiency and effectiveness of rangeland restoration in Namaqualand, South Africa. Plant Ecology, 218(1), pp.7-22. https://doi.org/10.1007/s11258-016-0644-3

391 Mills, A.J., Vyver, M.V.D., Gordon, I.J., Patwardhan, A., Marais, C., Blignaut, J., Sigwela, A. and Kgope, B., 2015. Prescribing innovation within a large-scale restoration programme in degraded subtropical thicket in South Africa. Forests, 6(11), pp.4328-4348. https://doi.org/10.3390/f6114328

392 Mills, A.J. and Cowling, R.M., 2006. Rate of carbon sequestration at two thicket restoration sites in the Eastern Cape, South Africa. Restoration Ecology, 14(1), pp.38-49. https://doi.org/10.1111/j.1526-100X.2006.00103.x

393 Powell, M., 2021. personal communications 09 April 2021.

394 Chakrabarti, S., 2014. The IFAD-GEF Advantage. Partnering for a sustainable world. IFAD, Rome, 38 pp. https://www.ifad.org/en/web/knowledge/-/publication/the-ifad-gef-advantage-partnering-for-a-sustainable-wor-1

395 Nicas J., 2021. A slow-motion climate disaster: the spread of barren land. The New York Times (03 Decemeber) https://www.nytimes.com/2021/12/03/world/americas/brazil-climate-change-barren-land.html

396 IFAD, 2017. Protecting the environment through sustainable production. IFAD (19 May) https://www.ifad.org/es/web/latest/-/story/protecting-the-environment-through-sustainable-production

397 Inter-American Institute for Cooperation on Agriculture, 2013. Development practices in Northeastern Brazil: the experiences of IFAD supported projects. Brasilia (Brazil,) Instituto interamericano de cooperación para la agricultura, 101 pp. http://repositorio.iica.int/handle/11324/3079

398 IFAD, 2017. Protecting the environment through sustainable production. IFAD (19 May) https://www.ifad.org/es/web/latest/-/story/protecting-the-environment-through-sustainable-production

399 Chakrabarti, S., 2014. The IFAD-GEF Advantage. Partnering for a sustainable world. IFAD, Rome, 38 pp. https://www.ifad.org/en/web/knowledge/-/publication/the-ifad-gef-advantage-partnering-for-a-sustainable-wor-1

400 Mansourian, S., Walters, G., and Gonzales, E., 2019. Identifying governance problems and solutions for forest landscape restoration in protected area landscapes. Parks, 25(1), 83-96. 10.2305/IUCN.CH.2019.PARKS-25-1SM.en

401 Mansourian, S., Géroux, H., Do Khac, E., and Vallauri, D., 2018. Lessons Learnt from 17 Years of Restoration in New Caledonia's Dry Tropical Forest. Field Series. Paris, France: WWF France. https://www.cen.nc/documents/22209/82590/Enseignements+de+17+ans+de+restauration+dans+les+for%C3%AAts+s%C3%A8ches+de+Nouvelle-Cal%C3%A9donie/80015579-0ddb-48c5-9dbf-5b958b9965c1

402 WWF, 2018. New hope for New Caledonia's dry forest. WWF News (12 December) https://wwf.panda.org/wwf_news/?340112/New-hope-for-New-Caledonias-dry-forest

403 Vallauri, D., do Khac, E. and Mansourian, S., 2019. Restoration in New Caledonia´s dry tropical forests. Case Study. WWF Forest Solutions (08 July) http://forestsolutions.panda.org/case-studies/restoration-in-new-caledonias-dry-tropical-forests

404 UNDP Pakistan, 2018. Sustainable Land Management Programme to Combat Desertification in Pakistan (SLM) - Phase II. UNDP in Pakistan. https://www.undp.org/content/dam/pakistan/docs/Project%20Briefs/August2018/ECCU/Project%20Brief%20-%20SLMP-Aug18.pdf

405 Alam, F., 2021. Combating twin challenges of desertification, food security through whopping plantation. Associated Press of Pakistan. (31 October) https://www.app.com.pk/features/combating-twin-challenges-of-desertification-food-security-through-whopping-plantation/

406 UNDP, 2021. Sustainable Land Management Program to Combat Desertification in Pakistan. Terminal Evaluation – SLMP II. 138 pp. https://erc.undp.org/evaluation/evaluations/detail/9563

407 Kamal, A., Yingjie, M., and Ali, A., 2019. Significance of billion tree naminami afforestation project and legal developments in forest sector of Pakistan. International Journal of Law and Society. Volume 1, Issue 4, November 2018 , pp. 157-165. doi: 10.11648/j.ijls.20180104.13

408 Khan, M., Hussain,S.K., Saad, H., Rukh, G., Ahmed, M.M., Ahmad, I., 2017. Third party monitoring of the billion trees afforestation project in Khyber Pakhtunkhwa Phase-II. WWF Pakistan. https://wwfasia.awsassets.panda.org/downloads/bttap_third_party_monitoring_report_1.pdf

409 Ullah, A., Sam, A. S., Sathyan, A. R., Mahmood, N., Zeb, A., and Kächele, H., 2021. Role of local communities in forest landscape restoration: Key lessons from the Billion Trees Afforestation Project, Pakistan. Science of The Total Environment, 772, 145613. https://doi.org/10.1016/j.scitotenv.2021.145613

410 Gul, A., 2017. One Billion Trees Planted in Pakistan's NW Province. VOA News (13 August). https://www.voanews.com/a/one-billion-trees-planted-in-pakistan-nw-province/3983609.html

411 Khan, N., Shah, S. J., Rauf, T., Zada, M., Yukun, C., and Harbi, J., 2019. Socioeconomic impacts of the billion trees afforestation program in Khyber Pakhtunkhwa Province, Pakistan. Forests, 10(8), 703. https://doi.org/10.3390/f10080703

412 Rauf, T., Khan, N., Shah, S. J., Zada, M., Malik, S. Y., Yukun, C., and Sadique, A., 2019. Poverty and Prosperity: Impact on Livelihood Assets of Billion Trees Afforestation Program in Khyber Pakhtunkhwa, Pakistan. Forests, 10(10), 916. https://doi.org/10.3390/f10100916

413 Ullah, I., Saleem, A., Ansari, L., Ali, N., Ahmad, N., Dar, N. M., and Din, N. U., 2020. Growth and survival of multipurpose species; assessing billion tree afforestation project (BTAP), the Bonn challenge initiative. Applied ecology and environmental research, 18(2), 2057-2072. https://doi.org/10.15666/aeer/1802_20572072

414 Hutt, R., 2018. Pakistan has planted over a billion trees. World Economic Forum (02 July) https://www.weforum.org/agenda/2018/07/pakistan-s-billion-tree-tsunami-is-astonishing

415 Ebrahim, Z., 2021. On World Environment Day - Pakistan showcases ecosystem restoration. Inter Press Service News Agency (05 June). http://www.ipsnews.net/2021/06/on-world-environment-day-pakistan-showcases-ecosystem-restoration/

416 Futurepolicy.org, 2017. Australia's Indigenous Protected Areas Programme. https://www.futurepolicy.org/healthy-ecosystems/australias-indigenous-protected-areas-programme-and-working-on-country-indigenous-rangers-programme

417 International Union for Conservation of Nature, 2017. Peatlands and climate change. Issues Brief (November). https://www.iucn-uk-peatlandprogramme.org/sites/default/files/header-images/171107%20Peatlands%20and%20Climate%20Change.pdf

418 Humpenöder, F., Karstens, K., Lotze-Campen, H., Leifeld, J., Menichetti, L., Barthelmes, A. and Popp, A., 2020. Peatland protection and restoration are key for climate change mitigation. Environmental Research Letters, 15(10), p.104093. https://doi.org/10.1088/1748-9326/abae2a

419 Tanovitskaya N. I., and Bambalov N. N., 2009. Modern state of peat deposits and mires use of Belarus. https://www.elibrary.ru/item.asp?id=42571976&

420 GEF, 2020. Conservation-oriented Management of Forests and Wetlands to Achieve Multiple Benefits. Global Environment Facility. https://www.thegef.org/projects-operations/projects/7993

421 UNDP Belarus, 2018. Belarus to prevent more than 5 million tons of CO2 emissions by peatland restoration. UNDP Belarus (11 December) https://www.by.undp.org/content/belarus/en/home/presscenter/pressreleases/2018/12/belarus-to-prevent-more-than-5-mln-tons-of-co2-emissions-by-peat.html

422 UNCCD, 2020. Peatland rehabilitation in Belarus in response to drought and sand storms. https://www.unccd.int/conventionregions/peatland-rehabilitation-belarus-response-drought-and-sand-storms

423 Marchenko Y.D., Nenashev R.A., Belash V.E., Kalinichenko S.A., 2017. The influence of the weather conditions on the occurrence of the summer forests fires in the belarusian sector of chernobyl npp exclusion zone. In Экологическая, промышленная и энергетическая безопасность-2017 (pp. 849-852) https://www.elibrary.ru/item.asp?id=32364340

424 Kuzmenkova N.V., Rozhkova A.K., Vorobyova T.A. Aerosol activity measurements associated with the burning of peat materials (evacuation zone of the Bryansk Region). Journal of Environmental Radioactivity, Том 216. https://colab.ws/articles/3868

425 Republic of Belarus, 2019. ЗАКОН РЕСПУБЛИКИ БЕЛАРУСЬ: Об охране и использовании торфяников. https://pravo.by/upload/docs/op/H11900272_1577394000.pdf

426 https://pravo.by/document/?guid=12551&p0=W22035886&p1=1

427 Frankfurt Zoological Society and BAHNA, 2020. Assessment of the tourist potential of the Belarusian Polesie. Minsk, pp.1–30. https://savepolesia.org/wp-content/uploads/2021/03/2020_Bahna_Tourism-potential-Belarusian-Polesia_en_full-report.pdf

428 Xu, J., Morris, P., Liu, J. and Holden, J., 2018. PEATMAP: Refining estimates of global peatland distribution based on a meta-analysis. CATENA, 160, pp.134-140. https://doi.org/10.1016/j.catena.2017.09.010

429 Seymour, F. and Samadhi, T., 2018. To Save Indonesia's Carbon-Rich Peatlands, Start by Mapping Them. World Resources Institute (29 January) https://www.wri.org/insights/save-indonesias-carbon-rich-peatlands-start-mapping-them

430 Chimner, R.A., Cooper, D.J., Wurster, F.C. and Rochefort, L., 2017. An overview of peatland restoration in North America: where are we after 25 years? Restoration Ecology, 25(2), pp.283-292. http://doi.org/10.1111/rec.12434

431 Cris, R. Buckmaster, S. Bain, C. and Reed, M. (Eds) 2014. Global Peatland Restoration demonstrating success. IUCN UK National Committee Peatland Programme, Edinburgh. https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/IUCNGlobalSuccessApril2014_0.pdf

432 O'Sullivan K., 2022. At least 7.5m tonnes of carbon protected by peatlands rehabilitated in 2021. The Irish Time (2 February) https://www.irishtimes.com/news/environment/at-least-7-5m-tonnes-of-carbon-captured-by-peatlands-rehabilitated-in-2021-1.4791340

433 Harris, N., Minnemeyer, S., Stolle, F. and Payne, O., 2015. Indonesia's Fire Outbreaks Producing More Daily Emissions than Entire US Economy. World Resources Institute (16 October) https://www.wri.org/insights/indonesias-fire-outbreaks-producing-more-daily-emissions-entire-us-economy

434 Puspitaloka, D., Kim, Y., Purnomo, H. and Fulé, P., 2021. Analysis of challenges, costs, and governance alternative for peatland restoration in Central Kalimantan, Indonesia. Trees, Forests and People, 6, p.100131. https://doi.org/10.1016/j.tfp.2021.100131

435 Jong H.N., 2019. Indonesia forest-clearing ban is made permanent, but labeled 'propaganda'. Mongabay (14 August) https://news.mongabay.com/2019/08/indonesia-forest-clearing-ban-is-made-permanent-but-labeled-propaganda/

436 Astuti, R., 2020. Fixing flammable Forest: The scalar politics of peatland governance and restoration in Indonesia. Asia Pacific Viewpoint, 61(2), pp.283-300. https://doi.org/10.1111/apv.12267

437 Harrison, M., et. al, 2019. Tropical forest and peatland conservation in Indonesia: Challenges and directions. People and Nature, 2(1), pp.4-28. https://doi.org/10.1002/pan3.10060

438 Ward, C., et. al, 2020. Smallholder perceptions of land restoration activities: rewetting tropical peatland oil palm areas in Sumatra, Indonesia. Regional Environmental Change, 21(1). https://doi.org/10.1007/s10113-020-01737-z

439 Giesen, W. 2013. Paludiculture: sustainable alternatives on degraded peat land in Indonesia. QANS Report on Activity 3.3. https://doi.org/10.13140/RG.2.2.15539.73760

440 Dohong, A., 2018. Implementing Peatland Restoration in Indonesia: Technical Policies, Interventions and Recent Progress. https://doi.org/10.13140/RG.2.2.32241.33125

441 Society for Ecological Restoration, (n.d.) Restoration Resource Center Indonesia: Central Kalimantan Peatlands Restoration Project. https://www.ser-rrc.org/project/indonesia-central-kalimantan-peatlands-restoration-project

442 Wetlands International, 2008. Provisional report- Central Kalimantan Peatland Project. Provisional report of the Central Kalimantan Peatland Project. Wetlands International https://www.wetlands.org/publications/provisional-report-of-the-central-kalimantan-peatland-project

443 Rieley, J. O., Notohadiprawiro, T., Setiadi, B., and Limin, S. H. 2008. Restoration of tropical peatland in Indonesia: why, where and how? Restoration of tropical peatlands, 20. Wageningen, Netherlands: Alterra - Wageningen University and Research Centre, and the EU INCO – RESTORPEAT Partnership. https://peatlands.org/assets/uploads/2019/06/ipc2008p240-244-rieley-restoration-of-tropical-peatland-in-indonesia.pdf

444 Novitasari N., Sujono J., Harto S., Maas A., and Jayadi R. 2018. Restoration of peat dome in ex-Mega rice project area in Central Kalimantan", AIP Conference Proceedings 1977, 040008. https://doi.org/10.1063/1.5042978

445 Jong, H.N., 2021. Indonesia renews peat restoration bid to include mangroves, but hurdles abound. Mongabay (05 January) https://news.mongabay.com/2021/01/indonesia-renews-peatland-mangrove-restoration-agency-brgm

446 Global Partnership on Forest and Landscape Restoration, 2021. Homepage. https://www.forestlandscaperestoration.org

447 Stanturf, J.A., Kleine, M., Mansourian, S., Parrotta, J., Madsen, P., Kant, P., Burns, J. and Bolte, A., 2019. Implementing forest landscape restoration under the Bonn Challenge: a systematic approach. Annals of Forest Science, 76(2), pp.1-21. https://doi.org/10.1007/s13595-019-0833-z

448 Besseau, P., Graham, S. and Christophersen, T., 2018. Restoring forests and landscapes: the key to a sustainable future. Global Partnership on Forest and Landscape Restoration, Vienna, pp.902762-97. https://www.forestlandscaperestoration.org/images/gpflr_final%2027aug.pdf

449 Bonn Challenge, 2020. Restore Our Future – the Bonn Challenge: Impact and Potential of Forest Landscape Restoration. IUCN, Gland. https://www.bonnchallenge.org/sites/default/files/resources/files/%5Bnode%3Anid%5D/Bonn%20Challenge%20Report.pdf

450 Ministerio de Ambiente y Energia – Republica de Costa Rica, 2019. Sistema Nacional de Información Ambiental de Costa Ric (SINIA CR) | Informe del Estado Ambiente. http://sinia.go.cr/informedelestadoambiente

451 GEF, 2020. Behold the power of restoring an ecosystem in Costa Rica's Jesús María River Basin. GEF (20 July). https://www.thegef.org/news/behold-power-restoring-ecosystem-costa-ricas-jes-s-mar-river-basin

452 Simelton, E.S., Catacutan, D.C., Dao, T.C., Dam, B.V. and Le, T.D., 2017. Factors constraining and enabling agroforestry adoption in Viet Nam: a multi-level policy analysis, Agroforestry Systems 9. https://doi.org/10.1007/s10457-016-9906-2

453 Nguyen, M.P., Pagella, T., Catacutan, D.C., Nguyen, T.Q. and Sinclair, F., 2021. Adoption of Agroforestry in Northwest Viet Nam: What Roles Do Social and Cultural Norms Play? Forests 12(4), 493. https://doi.org/10.3390/f12040493

454 Afr100, 2022. Energizing Degraded Land in the Congo Basin. https://afr100.org/content/energizing-degraded-land-congo-basin

455 Gonzalez A., 2021. 1 million trees planted to energize the Congo Basin forests. Global Landscape Forum, News (30 April) https://news.globallandscapesforum.org/51923/1-million-trees-planted-to-energize-the-congo-basin-forests

456 Center for International Forestry Research, (n.d.) Yangambi Engagement Landscape. https://www.cifor.org/yangambi/en

457 Alencar, A., Z Shimbo, J., Lenti, F., Balzani Marques, C., Zimbres, B., Rosa, M., Arruda, V., Castro, I., Fernandes Márcico Ribeiro, J.P., Varela, V. and Alencar, I., 2020. Mapping three decades of changes in the Brazilian savanna native vegetation using landsat data processed in the google earth engine platform. Remote Sensing, 12(6), p.924. https://doi.org/10.3390/rs12060924

458 Schmidt I., Mascia Vieira D.L., Sampaio A. et al., 2020. Grupo Restaura Cerrado - Cerrado Restoration Group |Project. ReserachGate https://www.researchgate.net/project/Grupo-Restaura-Cerrado-Cerrado-Restoration-Group

459 Sax S., 2020. Restaura Cerrado: Saving Brazil's savanna by reseeding and restoring it. Mongabay (14 December) https://news.mongabay.com/2020/12/restaura-cerrado-saving-brazils-savanna-by-reseeding-and-restoring-it

460 Urzedo, D.I.D., Piña-Rodrigues, F., Feltran-Barbieri, R., Junqueira, R.G. and Fisher, R., 2020. Seed networks for upscaling forest landscape restoration: is it possible to expand native plant sources in Brazil? Forests, 11(3), p.259. https://doi.org/10.3390/f11030259

461 Bizimana, I., 2018. Final Country Report of the LDN Target Setting Programme in Rwanda, Ministry of Lands and Forestry, Kigali, Rwanda. https://knowledge.unccd.int/sites/default/files/ldn_targets/2019-01/Rwanda%20LDN%20TSP%20Country%20Report.pdf

462 Ministry of Environment, Republic of Rwanda, 2019. Rwanda Forest Cover Mapping |Report November 2019. Government of Rwanda Publication. https://www.environment.gov.rw/fileadmin/user_upload/Moe/Publications/Reports/Forest_cover_report_2019.pdf

463 Bizimana, I., 2018. Final Country Report of the LDN Target Setting Programme in Rwanda, Ministry of Lands and Forestry, Kigali, Rwanda. https://knowledge.unccd.int/sites/default/files/ldn_targets/2019-01/Rwanda%20LDN%20TSP%20Country%20Report.pdf

464 Ministry of Lands and Forestry, Republic of Rwanda, 2018. Forest Sector Strategic Plan 2018-2024. Ministry of Lands and Forestry, Kigali, Rwanda https://environment.prod.risa.rw/fileadmin/user_upload/Moe/Publications/Laws/Forest_Sector_strategy_2018-2014__4_.pdf

465 Global Forest Generation, 2022. Global Forest Generation Homepage. https://www.globalforestgeneration.org

466 Rai, P.B., Sears, R.R., Dukpa, D., Phuntsho, S., Artati, Y. and Baral, H., 2020. Participatory Assessment of Ecosystem Services from Community-Managed Planted Forests in Bhutan. Forests, 11(10), p.1062. https://doi.org/10.3390/f11101062

467 Mollins J., 2020. Creative community-based policies in Bhutan reveal benefits of planted forests. Forests News (22 October) https://forestsnews.cifor.org/68509/creative-community-based-policies-in-bhutan-reveal-benefits-of-planted-forests

468 Kuensel, 2021. Biodiversity Bill ensures benefits from genetic and biological resources. Kuensel Online (07 December) https://kuenselonline.com/biodiversity-bill-ensures-benefits-from-genetic-and-biological-resources/

469 Curtis, P., Slay, C., Harris, N., Tyukavina, A. and Hansen, M., 2018. Classifying drivers of global forest loss. Science, 361(6407), pp.1108-1111. 8 https://doi.org/10.1126/science.aau3445

470 University of Göttingen, 2020. Coffee, cocoa and vanilla: An opportunity for more trees in tropical agricultural landscapes. ScienceDaily (15 June) www.sciencedaily.com/releases/2020/06/200615184148.htm

471 Martin, D., Osen, K., Grass, I., Hölscher, D., Tscharntke, T., Wurz, A. and Kreft, H., 2020. Land-use history determines ecosystem services and conservation value in tropical agroforestry. Conservation Letters. https://doi.org/10.1111/conl.12740

472 National Agroforestry Center of the US Department of Agriculture, (n.d.) Forest Farming. https://www.fs.usda.gov/nac/practices/forest-farming.php

473 Weisse, M. and Goldman, L., 2021. Just 7 Commodities Replaced an Area of Forest Twice the Size of Germany Between 2001 and 2015. Global Forest Institute (11 February) https://www.globalforestwatch.org/blog/commodities/global-deforestation-agricultural-commodities

474 Atangana, A.R., Gnangoh, J.Z., Yao, A.K., Kouakou, T.D.A., Mian Ndri Nda, A. and Kouamé, C., 2021. Rebuilding Tree Cover in Deforested Cocoa Landscapes in Côte d'Ivoire: Factors Affecting the Choice of Species Planted. Forests, 12(2), p.198. https://doi.org/10.3390/f12020198

475 Projeto RECA, (n.d.) Projeto Reca Homepage - Quality, Flavor and Origin: Amazonian products our cooperative brings to you. https://www.projetoreca.com.br/en

476 Barth B., and Milhorance F., 2021. These farmers show that agriculture in the Amazon doesn't have to be destructive. National Geographic (June 28) https://www.nationalgeographic.com/environment/article/these-farmers-show-that-agriculture-in-the-amazon-doesnt-have-to-be-destructive

477 Gorongosa, 2020.Gorongosa National Park Homepage. https://gorongosa.org

478 Hoffner E., 2020. Gorongosa National Park is being reforested via coffee and agroforestry. Mongabay (15 October) https://news.mongabay.com/2020/10/gorongosa-national-park-is-being-reforested-via-coffee-and-agroforestry

479 Wilson, B., Mills, M., Kulikov, M. and Clubbe, C., 2019. The future of walnut–fruit forests in Kyrgyzstan and the status of the iconic Endangered apple Malus niedzwetzkyana," Oryx. Cambridge University Press, 53(3), pp. 415–423. https://doi.org/10.1017/S0030605318001230

480 Muller N., 2018. Kyrgyzstan's ancient walnut forest living through uncertain times. Eurasianet (9 October). https://eurasianet.org/kyrgyzstans-ancient-walnut-forest-living-through-uncertain-times

481 Orozumbekov, A., Musuraliev, T., Toktoraliev, B., Kysanov, A., Shamshiev, B., and Sultangaziev, O., 2009. Forest rehabilitation in Kyrgyzstan. IUFRO World Series, 20(4), 131-182. https://www.iufro.org/download/file/7407/5123/Kyrgyzstan_pdf

482 GIZ Regional Programme for Sustainable and Climate Sensitive Land Use for Economic Development in Central Asia, 2018. Community-based management of walnut forests and pastures: Kyrgyzstan. Landuse-ca. https://www.landuse-ca.org/?p=6441&lang=en

483 GIZ, 2019. Community-based walnut forest and pasture management in the South of Kyrgyzstan: Promoting biodiversity conservation and supporting local income generation. https://www.giz.de/en/worldwide/29911.html

484 Current Conservation, 2018. The critical role of agroforestry in forest and landscape restoration. In: Current Conservation Vol 12 March 2018. https://www.currentconservation.org/the-critical-role-of-agroforestry-in-forest-and-landscape-restoration

485 Virapongse, A., 2017. Smallholders and Forest Landscape Restoration in Upland Northern Thailand. International Forestry Review, vol. 19/4 pp. 102–119. https://doi.org/10.1505/146554817822330533

486 Serendipalm, (n.d.) Serendipalm Homepage. https://serendipalm.com

487 Renature, 2020. Creating the 'new normal' with palm oil agroforestry. Renature (16 November) https://www.renature.co/articles/palm-oil-agroforestry

488 United Nations Development Programme, 2012. Honey Care Africa, Kenya. Equator Initiative Case Study Series. New York. https://sgp.undp.org/resources-155/award-winning-projects/379-honey-care-africa/file.html

489 Oro Verde, Defensores de la Naturaleza, Heifer International Guatemala, 2019. ForestValues Innovative partnerships for forest restoration. Fourth Newsletter – September 2019. Regenwald-schuetzen. https://www.regenwald-schuetzen.org/fileadmin/user_upload/pdf/Projekt/WaldGewinn/newsletter4-waldgewinn-eng-web.pdf

490 World Business Council for Sustainable Development, 2012. Biodiversity and ecosystem services scaling up business solutions: Company case studies that help achieve global biodiversity targets. WBCSD, Geneva. https://docs.wbcsd.org/2012/09/BiodiversityAndEcosystemServices.pdf

491 Giudice Badari, C., Bernardini, L. E., de Almeida, D. R., Brancalion, P. H., Cesar, R. G., Gutierrez, et al., 2020. Ecological outcomes of agroforests and restoration 15 years after planting. Restoration Ecology, 28(5), 1135-1144. https://doi.org/10.1111/rec.13171

492 Poorter, L., Craven, D., Jakovac, C.C., van der Sande, M.T., Amissah, L., Bongers, F., Chazdon, R.L., Farrior, C.E., Kambach, S., Meave, J.A. and Muñoz, R., 2021. Multidimensional tropical forest recovery. Science, 374(6573), pp.1370-1376. https://www.science.org/doi/10.1126/science.abh3629

493 Badari, C., Bernardini, L., and Viani, R., 2019. Coffee agroforestry as an alternative for tropical forest restoration: comparing with conventional restoration planting Take away lessons. https://doi.org/10.13140/RG.2.2.18596.63369

494 ForestWise, (n.d.) Rainforestvalue: Better for nature, people and planet. https://www.forestwise.earth/rainforestvalue

495 Mirova, 2021. Land Degradation Neutrality Fund: Impact Report 2020. Mirova https://www.mirova.com/en/ideas/ldn-land-degradation-neutrality-fund-impact-report-2020

496 Hending, D., Andrianiaina, A., Maxfield, P., Rakotomalala, Z. and Cotton, S., 2019. Floral species richness, structural diversity and conservation value of vanilla agroecosystems in Madagascar. African Journal of Ecology, 58(1), pp.100-111. 2 https://doi.org/10.3390/d14020106

497 Martin, D.A., Wurz, A., Osen, K. et al., 2021. Shade-Tree Rehabilitation in Vanilla Agroforests is Yield Neutral and May Translate into Landscape-Scale Canopy Cover Gains. Ecosystems 24, 1253-1267. https://doi.org/10.1007/s10021-020-00586-5

498 Schwab, D., Wurz, A., Grass, I., Rakotomalala, A., Osen, K., Soazafy, M., Martin, D. and Tscharntke, T., 2020. Decreasing predation rates and shifting predator compositions along a land-use gradient in Madagascar's vanilla landscapes. Journal of Applied Ecology, 58(2), pp.360-371. https://doi.org/10.1111/1365-2664.13766

499 Duke Lemur Center, 2020. The Story of Vanilla. https://lemur.duke.edu/engage/virtual-programs/subscription/9-2020-ll2

500 UN, 2020. United Nations Food Systems Summit 2021: Action Track Discussion Starter Action Track 3 – Boost Nature-Positive Food Production at Scale. https://www.un.org/sites/un2.un.org/files/unfss-at3-discussion_starter-dec2020.pdf

501 Rosset, P.M., Machín Sosa, B., Roque Jaime, A.M. and Ávila Lozano, D.R., 2011. The Campesino-to-Campesino agroecology movement of ANAP in Cuba: social process methodology in the construction of sustainable peasant agriculture and food sovereignty. Journal of Peasant Studies, 38(1), pp.161–191. https://doi.org/10.1080/03066150.2010.538584

502 Freire, P., 2018. Pedagogy of the oppressed. USA, Bloomsbury publishing. https://www.bloomsbury.com/us/pedagogy-of-the-oppressed-9781501314162

503 Giroux, H.A., 2010. Rethinking Education as the Practice of Freedom: Paulo Freire and the Promise of Critical Pedagogy. Policy Futures in Education, 8(6), pp.715–721. https://doi.org/10.2304/pfie.2010.8.6.715

504 Lucantoni D., 2020. Transition to agroecology for improved food security and better living conditions: case study from a family farm in Pinar del Río, Cuba. Agroecology and Sustainable Food Systems Vol.44 :9, 1124-1161. https://doi.org/10.1080/21683565.2020.1766635

505 Chang, Y., 2021. Scaling sustainable agriculture: the Farmer-to-Farmer Agroecology movement in Cuba. Oxford (UK), Oxfam. p.24. https://doi.org/10.21201/2020.7024

506 GEF, 2015. Rehabilitation of Degraded Agricultural Lands in Kandy, Badulla and Nuwara Eliya Districts in the Central Highlands (CH) | Project details. Global Environment Facility. https://www.thegef.org/project/rehabilitation-degraded-agricultural-lands-kandy-badulla-and-nuwara-eliya-districts-central

507 Sri Lanka Overview of Conservation Approaches and Technologies, 2019. FAO/GEF Project on rehabilitation of degraded agricultural lands in Kandy, Badulla and Nuwara Eliya Districts in the Central Highlands GCP/SRL/063/GFF. SriCAT. https://sricat.net/index.php/en/about-us/51-projects-activities/152-fao-gef-project-on-rehabilitation-of-degraded-agricultural-lands-in-kandy-badulla-and-nuwara-eliya-districts-in-the-central-highlands-gcp-srl-063-gff

508 Bamunuarachchi, B.A.D.S., Hitihamu, S. and Lurdu, M.S., 2019. Good Agricultural Practices (GAP) in Sri Lanka: Status, Challenges and Policy Interventions. HARTI Research Report 227. Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo. http://www.harti.gov.lk/images/download/reasearch_report/new1/report_no_227.pdf

509 Malkanthi, S.H.P., Thenuwara, A.M. and Weerasinghe, W.A.R.N., 2021. Attitude of Vegetable Farmers in Galle District in Sri Lanka Towards Good Agricultural Practices (GAP). Contemporary Agriculture, 70(1-2), pp.54-66. https://doi.org/10.2478/contagri-2021-0010

510 FAO, 2020. Healthy soils in Ukraine: 2019. Integrated Natural Resources Management in Degraded Landscapes in the Forest-Steppe and Steppe Zones of Ukraine. FAO. https://www.fao.org/documents/card/en/c/ca7464en

511 FAO, 2022. Global Farmer Fiel School Platform. FAO. http://www.fao.org/farmer-field-schools/overview/en

512 Osumba, J., Recha, J. and Oroma, G., 2021. Transforming Agricultural Extension Service Delivery through Innovative Bottom–Up Climate-Resilient Agribusiness Farmer Field Schools. Sustainability, 13(7), p.3938. https://doi.org/10.3390/su13073938

513 van den Berg, H., Phillips, S., Dicke, M. and Fredrix, M., 2020. Impacts of farmer field schools in the human, social, natural and financial domain: a qualitative review. Food Security, 12(6), pp.1443-1459. https://doi.org/10.1007/s12571-020-01046-7

514 Ibrahim, A., Abaidoo, R.C., Fatondji, D. and Opoku, A., 2015. Hill placement of manure and fertilizer micro-dosing improves yield and water use efficiency in the Sahelian low input millet-based cropping system. Field Crops Research, 180, pp.29-36. https://doi.org/10.1016/j.fcr.2015.04.022

515 CGAR, (n.d) Innovation explorer: Fertilizer microdosing. CGIAR. https://www.cgiar.org/innovations/fertilizer-microdosing

516 Bharucha, Z.P., Mitjans, S.B. and Pretty, J., 2020. Towards redesign at scale through zero budget natural farming in Andhra Pradesh, India. International Journal of Agricultural Sustainability, 18(1), pp.1-20. https://doi.org/10.1080/14735903.2019.1694465

517 UNEP, 2020. What does the UN Environment Programme bring to the table in the zero-budget natural farming debate? UNEP News and Stories (24 February). https://www.unep.org/news-and-stories/story/what-does-un-environment-programme-bring-table-zero-budget-natural-farming

518 Khadse, A., Rosset, P.M., Morales, H. and Ferguson, B.G., 2018. Taking agroecology to scale: The zero budget natural farming peasant movement in Karnataka, India. The Journal of Peasant Studies, 45(1), pp.192-219. https://doi.org/10.1080/03066150.2016.1276450

519 Le Coq, J.F., Sabourin, E., Bonin, M., Freguin-Gresh, S., Marzin, J., Niederle, P., Patrouilleau, M.M. and Vásquez, L., 2020. Public policy support for agroecology in Latin America: Lessons and perspectives. Global Journal of Ecology, 5(1): p. 129-138. https://doi.org/10.17352/gje.000032

520 FAO, 2022. GIAHS Global Important Agricultural Heritage Systems. FAO. http://www.fao.org/giahs/en

521 Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M. and Rieseberg, L.H., 2018. Trends in global agricultural land use: implications for environmental health and food security. Annual review of plant biology, 69, pp.789-815. https://doi.org/10.1146/annurev-arplant-042817-040256

522 Yang, Y., Hobbie, S.E., Hernandez, R.R., Fargione, J., Grodsky, S.M., Tilman, D., Zhu, Y.G., Luo, Y., Smith, T.M., Jungers, J.M. and Yang, M., 2020. Restoring abandoned farmland to mitigate climate change on a full earth. One Earth, 3(2), pp.176-186. https://doi.org/10.1016/j.oneear.2020.07.019

523 Xie, Z., Game, E.T., Hobbs, R.J., Pannell, D.J., Phinn, S.R. and McDonald-Madden, E., 2020. Conservation opportunities on uncontested lands. Nature Sustainability, 3(1), pp.9-15. https://doi.org/10.1038/s41893-019-0433-9

524 Hardy, M.J., Fitzsimons, J.A., Bekessy, S.A. and Gordon, A., 2018. Purchase, protect, resell, repeat: an effective process for conserving biodiversity on private land? Frontiers in Ecology and the Environment, 16(6), pp.336-344. https://doi.org/10.1002/fee.1821

525 World Land Trust, (n.d.) World Land Trust Homepage. https://www.worldlandtrust.org

526 Valkó, O., Deák, B., Török, P., Kelemen, A., Miglécz, T., Tóth, K. and Tóthmérész, B., 2016. Abandonment of croplands: problem or chance for grassland restoration? Case studies from Hungary. Ecosystem Health and Sustainability, 2(2), p.e01208. https://doi.org/10.1002/ehs2.1208

527 Deutsche Gesellschaft für International Zusammenarbeit, (n.d.) Support to community based natural resource management: Namibia. GIZ. https://www.giz.de/en/worldwide/60440.html

528 Scents of Namibia, 2018. Kunene Conservancies Indigenous Natural Products Trust - KCINP Trust. http://scentsofnamibia.com/kcinp-trust/

529 Hou, F., Xiao, J. and Nan, Z., 2002. Eco-restoration of abandoned farmland in the Loess Plateau. Ying yong sheng tai xue bao. August 13(8):923-9 pp.923-929. https://pubmed.ncbi.nlm.nih.gov/12418248

530 Bennun, L., van Bochove, J., Ng, C., Fletcher, C., Wilson, D., Phair, N., and Carbone, G., 2021. Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers. Gland, Switzerland: IUCN and Cambridge, UK: The Biodiversity Consultancy. https://portals.iucn.org/library/node/49283

531 Silicon Ranch, 2022. Silicon Ranch launches Regenerative Energy. https://www.siliconranch.com/silicon-ranch-launches-regenerative-energy

532 Solar Builder, 2020. How solar farms can be regenerative for soil and sequester more carbon. Solar Builder (06 February). https://solarbuildermag.com/operations-maintenance/how-solar-farms-can-be-regenerative-for-soil-and-sequester-more-carbon

533 Astronergy/Chint Solar, 2021. Astronergy/Chint Solar Homepage. https://energy.chint.com/en

534 Xin Z., 2021. Solar park brings succor to Qinghai. China Daily (23 February) https://www.chinadaily.com.cn/a/202102/23/WS60345656a31024ad0baaa55a.html

535 GEF and IFAD, 2021. Good Practice Brief: Renewable Energy Technology for Smallholder Farmers. GEF Secretariat https://www.thegef.org/publications/good-practice-brief-renewable-energy-technology-smallholder-farmers

536 Barua, K., Sehgal, K. and Meng, S., 2021. Promoting renewable energy technologies for small-scale farmers in Cambodia. IFAD (29 June) https://www.ifad.org/en/web/latest/-/cambodia-sret

537 Namibia University of Science and Technology, 2021. Biomass Utilisation by Sustainable Harvest (BUSH) Project Closure Workshop, NUST. https://www.dasnamibia.org/?wpfb_dl=145

538 Laufs, J., 2017. Rangeland Restoration through Bush Control. Panorama (12 June). https://panorama.solutions/en/solution/rangeland-restoration-through-bush-control

539 New Era Staff, 2016. Namibia: N$30 billion to restore rangelands. Land Portal (08 February). https://www.landportal.org/news/2016/02/namibia-n30-billion-restore-rangelands

540 Namibia Nature Foundation, 2016. Assessment of the macroeconomic benefits of de-bushing in Namibia. NNF Policy brief. https://panorama.solutions/sites/default/files/policy_brief_national_eld_0.pdf

541 De-bushing Advisory Service, Deutsche Gesellschaft für International Zusammenarbeit, 2021. Success Stories from the Field. Bush Control and Biomass Utilisation in Namibia. DAS Namibia https://www.dasnamibia.org/?wpfb_dl=136

542 Deutsche Gesellschaft für International Zusammenarbeit, 2021. Controlling bush encroachment to support rural livelihoods, Namibia. GIZ. https://www.giz.de/en/worldwide/28648.html

543 Johnsen, K.I., M. Niamir-Fuller, A. Bensada, and A. Waters-Bayer. 2019. A case of benign neglect: Knowledge gaps about sustainability in pastoralism and rangelands. United Nations Environment Programme and GRID-Arendal, Nairobi and Arendal. https://www.grida.no/publications/428

544 Köhler-Rollefson, I., 2020. Accounting for pastoralists: Why is it important and how to do it?. League for Pastoral Peoples and Endogenous Livestock Development, LIFE Network. http://www.pastoralpeoples.org/thematic/accounting-for-pastoralists-studies

545 Matampash, K., 1993. The Maasai of Kenya. In Davis, S. H. (Ed.), Indigenous views of land and the environment (World Bank Discussion Papers No. 188), pp. 31–44. The World Bank. https://documents1.worldbank.org/curated/en/720271468741314548/pdf/multi-page.pdf

546 Fratkin, E., 1994. Pastoral land tenure in kenya: Maasai, samburu, boran, and rendille experiences, 1950-1990. Nomadic peoples 34/35:1994, pp.55-68. https://www.jstor.org/stable/43124072

547 Ontiri, E. and Robinson, L.W., 2018. Community-based rangeland management in Shompole and Olkiramatian group ranches, Kenya: Taking successes in land restoration to scale project. ILRI Project Report, Nairobi. https://www.ilri.org/publications/community-based-rangeland-management-shompole-and-olkiramatian-group-ranches-kenya

548 Robinson, L.W., Eba, B., Flintan, F., Frija, A., Nganga, I.N., Ontiri, E.M., Sghaier, M., Abdu, N.H. and Moiko, S.S., 2021. The Challenges of Community-Based Natural Resource Management in Pastoral Rangelands. Society & Natural Resources 34(9), pp.1-19. https://doi.org/10.1080/08941920.2021.1946629

549 Jonckheere, S., Liversage, H. and Rota, A., 2017. Pastoralism and land tenure security: lessons from IFAD-supported projects. Paper prepared for presentation at the 2017 WORLD BANK CONFERENCE ON LAND AND POVERTY, Washington DC, March 20-24, 2017. IFAD. https://www.oicrf.org/-/pastoralism-and-land-tenure-security-lessons-from-ifad-supported-projects

550 Heaps, D., 2019. Sami land rights and policy-driven recognition threats. Henry M. Jackson School of International Studies, University of Washington (27 June). https://jsis.washington.edu/news/sami-land-rights-and-policy-driven-recognition-threats

551 Damonte, G., Glave, M., Rodríguez, S. and Ramos, 2016. A. The evolution of collective land tenure regimes in pastoralist societies: Lessons from Andean countries. Grupo de Análisis para el Desarrollo (GRADE) IDS Working Paper 480. Institute of Development Studies. https://doi.org/10.13140/RG.2.1.1044.6967

552 Bioveins, Biodiversa, (n.d.) Urban Pastoralism. Bioveins. https://bioveins.eu/blog/urban-pastoralism

553 Triboi R.M., 2021. Greening cities: the role of urban pastoralism in Romania. Pastres (26 March). https://pastres.org/2021/03/26/greening-cities-the-role-of-urban-pastoralism-in-romania

554 Les Bergers Urbains, (n.d.) Les Bargers Urbains Homepage. https://www.bergersurbains.com

555 Bioveins, Biodiversa, (n.d.) Urban Pastoralism. Bioveins. https://bioveins.eu/blog/urban-pastoralism

556 Kington T., 2008. Sheep replace lawn mowers in Turin parks. The Guardian (07 April). https://www.theguardian.com/world/2008/apr/07/italy.wildlife

557 Canadian Centre for Architecture, (n.d.) Sheep and lambs eat city parks. CCA. https://www.cca.qc.ca/actions/actions/sheep-and-lambs-eat-city-parks

558 EUROPARC Federation, 2022. Case Study: Enhance controlled grazing as a cost-effective and ecological tool for fire prevention in Collserola Natural Park. EUROOPARK Federation. https://www.europarc.org/case-studies/enhance-controlled-grazing-cost-effctive-ecological-tool-fire-prevention-collserola-natural-park

559 KSTA, 2013. Rhine bank in Niederkassel Sheep for flood protection. KSTA (24 July). https://www.ksta.de/region/rhein-sieg-bonn/niederkassel/rheinufer-in-niederkassel-schafe-fuer-den-hochwasserschutz-2615848?cb=1627472175840

560 Keys, P., Wang-Erlandsson, L. and Gordon, L., 2018. Megacity precipitationsheds reveal tele-connected water security challenges. PLOS ONE 13(3), p.e0194311. https://doi.org/10.1371/journal.pone.0194311

561 Abell, R., Boccaletti, G., Bremer, L., Chapin, E., Erickson-Quiroz, A., Higgins, J., Johnson, J., Kang, S., Karres, N., Lehner, B., McDonald, R., Raepple J., Shemie D., Simmons, E., Sridhar, A., Vigerstøl,K., Vogl, A., and Sylvia Wood, S., 2017. Beyond the Source: The Environmental, Economic and Community Benefits of Source Water Protection. The Nature Conservancy, Arlington. https://www.nature.org/content/dam/tnc/nature/en/documents/BeyondtheSource_ExecSummary_FINAL.pdf

562 McDonald, R., Weber, K., Padowski, J., Boucher, T. and Shemie, D., 2016. Estimating watershed degradation over the last century and its impact on water-treatment costs for the world's large cities. PNAS 113(32), pp.9117-9122. https://doi.org/10.1073/pnas.1605354113

563 He, C., Liu, Z., Wu, J., Pan, X., Fang, Z., Li, J. and Bryan, B., 2021. Future global urban water scarcity and potential solutions. Nature Communications 12(1). https://doi.org/10.1038/s41467-021-25026-3

564 McDonald, R. I., Weber, K., Padowski, J., Flörke, M., Schneider, C., Green, P. A., et al., 2014. Water on an urban planet: Urbanization and the reach of urban water infrastructure. Global environmental change, 27, 96-105. https://doi.org/10.1016/j.gloenvcha.2014.04.022

565 McDonald, R.I., and Shemie D., 2014. Urban Water Blueprint: Mapping conservation solutions to the global water challenge. The Nature Conservancy: Washington, D.C. https://www.nature.org/content/dam/tnc/nature/en/documents/Urban_Water_Blueprint.pdf

566 Ernst, C., Gullick, R., and Nixon, K., 2004. Conserving forests to protect water. Opflow, 30(5), 1-7. https://doi.org/10.1002/j.1551-8701.2004.tb01752.x

567 Al Radif, A., 1999. Integrated water resources management (IWRM): an approach to face the challenges of the next century and to avert future crises. Desalination, 124(1-3), 145-153. https://doi.org/10.1016/S0011-9164(99)00099-5

568 International Water Association, 2021. Basin Stories: Upper Tana-Nairobi Water Fund. IWA https://iwa-network.org/upper-tana-nairobi-water-fund

569 The Nature Conservancy, 2015. Upper Tana-Nairobi Water Fund Business Case. Version 2. The Nature Conservancy, Nairobi. https://www.nature.org/content/dam/tnc/nature/en/documents/Nairobi-Water-Fund-Business-Case_FINAL.pdf

570 The Nature Conservancy, 2020. Upper Tana-Nairobi Water Fund Trust Innovation at the Nexus of Conservation, Water, Food, Energy, And Business. Panorama Solutions. https://panorama.solutions/sites/default/files/2020_utnwf_annual_report_3.pdf

571 Richards, R. C., Kennedy, C. J., Lovejoy, T. E., and Brancalion, P. H., 2017. Considering farmer land use decisions in efforts to 'scale up' Payments for Watershed Services. Ecosystem Services, 23, 238-247. https://doi.org/10.1016/j.ecoser.2016.12.016

572 Richards, R. C., Rerolle, J., Aronson, J., Pereira, P. H., Gonçalves, H., and Brancalion, P. H., 2015. Governing a pioneer program on payment for watershed services: Stakeholder involvement, legal frameworks and early lessons from the Atlantic Forest of Brazil. Ecosystem Services, 16, 23-32. https://doi.org/10.1016/j.ecoser.2015.09.002

573 Cassola, R., 2010. TEEBcase: Payments and technical support for reforestation and soil conservation for watershed protection, Brazil. https://www.eea.europa.eu/atlas/teeb/payments-and-technical-support-for/view

574 McDonald, R.I., and Shemie D., 2014. Urban Water Blueprint: Mapping conservation solutions to the global water challenge. The Nature Conservancy: Washington, D.C. https://www.nature.org/content/dam/tnc/nature/en/documents/Urban_Water_Blueprint.pdf

575 Koehorst, M., 2020. Nature-based Solutions for sustainable drinking water sources. Panorama solutions (30 October). https://panorama.solutions/en/solution/nature-based-solutions-sustainable-drinking-water-sources

576 Beijing Forest Society, (n.d.). Forest Landscape and Livelihood Project. http://www.bjfs.org.cn/en/product/44.mhtml

577 Jia L., and Emerton L., 2012. Moving closer to nature: Lessons for landscapes and livelihoods from the Miyun landscape, China. Gland, Switzerland: IUCN. vi+32pp. https://portals.iucn.org/library/sites/library/files/documents/2012-024.pdf

578 Bank aus Verantwortung, (n.d.). North China Desertification Control Programme, Ecological Landscape Restoration in Water Catchment Areas (Miyun) Sub-Project. KFW. https://www.kfw-entwicklungsbank.de/Evaluierungsbericht/Evaluierungen/%C3%96kologische-Landschaftssanierung-in-Wassereinzugsgebieten-(Miyun)/index-2.html

579 Koehorst M., 2020. The Greater Cape Town Water Fund. Panorama solutions (15 October). https://panorama.solutions/en/solution/greater-cape-town-water-fund

580 Stafford L, Shemie D., Timm Kroeger T., Baker T, Apse C. Turpie, J., and Forsythe, K., 2019. The Greater Cape Town Water Fund. Assessing the return on investment for ecological infrastructure restoration. https://doi.org/10.13140/RG.2.2.23814.11844

581 The Nature Conservancy, 2020. Greater Cape Town Water Fund Securing Water Through Nature, Fact Sheet. Panorama Solutions. https://panorama.solutions/sites/default/files/gctwf_fact_sheet_september_2020_0.pdf

582 Agua Tica, 2019. Agua Tica Homepage. https://www.aguatica.org/homeeng

583 Fundecor, 2019. Costa Rican Initiative Selected Among the Five Best in the World for Water Protection. Fundecor (30 September). https://www.fundecor.org/post/2019/09/30/costaricaninitiativeamongthefivebestintheworld

584 Koehorst M., 2020. Protecting critical watersheds through scientific evidence, cross-sectoral collaboration and community action. Panorama solutions (15 October). https://panoramatest.tbodev.de/en/solution/protecting-critical-watersheds-through-scientific-evidence-cross-sectoral-collaboration-and

585 McDonald, R.I., and Shemie D., 2014. Urban Water Blueprint: Mapping conservation solutions to the global water challenge. The Nature Conservancy: Washington, D.C. https://www.nature.org/content/dam/tnc/nature/en/documents/Urban_Water_Blueprint.pdf

586 Business Mirror, 2020. Thousands of trees to reforest Ipo Watershed in 2021. Business Mirror (27 December). https://businessmirror.com.ph/2020/12/27/thousands-of-trees-to-reforest-ipo-watershed-in-2021

587 Call B., 2021. Another 1M trees eyed to be planted this year. Philippine News Agency (PNA) (23 June). https://www.pna.gov.ph/articles/1144707

588 WWF, (n.d.) IPO Watershed. WWF Philippines. https://wwf.org.ph/what-we-do/water/ipo-watershed

589 Turner, R. and Daily, G., 2007. The Ecosystem Services Framework and Natural Capital Conservation. Environmental and Resource Economics, 39(1), pp.25-35. https://doi.org/10.1007/s10640-007-9176-6

590 Pires, M., 2004. Watershed protection for a world city: the case of New York. Land Use Policy, 21(2), 161-175. https://doi.org/10.1016/j.landusepol.2003.08.001

591 Vintinner, E. C., 2008. Thirsty metropolis: A case study of New York City's drinking water. Lessons in Conservation Vol. 2 110-132. Network of Conservation Educators and Practitioners, Center for Biodiversity and Conservation, American Museum of Natural History https://www.amnh.org/content/download/141365/2285409/file/LinC2_NYCCaseStudy.pdf

592 McPhearson, T., Hamstead, Z. A., and Kremer, P., 2014. Urban ecosystem services for resilience planning and management in New York City. Ambio, 43(4), 502-515. https://doi.org/10.1007/s13280-014-0509-8

593 Lee-Smith, D., Prain, G., Cofie, O., van Veenhuizen, R. and Karanja, N., 2019. Urban and peri-urban farming systems: feeding cities and enhancing resilience. In Farming Systems and Food Security in Africa (pp. 504-531). Routledge. https://doi.org/10.4324/9781315658841

594 Nkrumah, B., 2019. Africa's future: Demarginalizing urban agriculture in the era of climate change. Future of Food: Journal on Food, Agriculture and Society, 7(1), pp.8-20. https://doi.org/10.17170/kobra-2018122072

595 Beach M., 2013. Urban Agriculture Increases Food Security for Poor People in Africa. PRB (04 April). https://www.prb.org/resources/urban-agriculture-increases-food-security-for-poor-people-in-africa

596 Dimitri, C., Oberholtzer, L. and Pressman, A., 2016. Urban agriculture: connecting producers with consumers. British Food Journal. Vol. 118 No. 3, pp. 603-617. https://doi.org/10.1108/BFJ-06-2015-0200

597 Gore, C.D., 2018. How African cities lead: Urban policy innovation and agriculture in Kampala and Nairobi. World Development, Elsevier, vol. 108(C), pages 169-180. https://doi.org/10.1016/j.worlddev.2018.03.011

598 https://ruaf.org/news/city-region-food-systems-to-cope-with-covid-19-and-other-pandemic-emergencies

599 Simatele, D.M. and Binns, T., 2008, March. Motivation and marginalization in African urban agriculture: The case of Lusaka, Zambia. In Urban forum Vol. 19, No. 1, pp. 1-21. https://doi.org/10.1007/s12132-008-9021-1

600 Lee-Smith, D., 2010. Cities feeding people: an update on urban agriculture in equatorial Africa. Environment and urbanization, 22(2), pp.483-499. https://doi.org/10.1177/0956247810377383

601 ZEA Hungry Goods, (n. d.) Mexico: Cultiva Ciudad. https://www.zeahungrygoods.com/cultiva-ciudad

602 Castillo, R.M. and Crisman, T.L., 2019. The role of Green Infrastructure in Water, Energy and Food Security in Latin America and the Caribbean. IDB. http://doi.org/10.18235/0001920

603 European Commission, 2020. Biodiversity strategy for 2030. https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en

604 Infarm, 2022. Infarm homepage. https://www.infarm.com/en

605 Usher, M., Huck, J., Clay, G., Shuttleworth, E. and Astbury, J., 2020. Broaching the brook: Daylighting, community and the 'stickiness' of water. Environment and Planning E: Nature and Space, p.2514848620959589. https://doi.org/10.1177/2514848620959589

606 Khirfan, L., Peck, M.L. and Mohtat, N., 2020. Digging for the truth: A combined method to analyze the literature on stream daylighting. Sustainable Cities and Society, 59, p.102225. https://doi.org/10.1016/j.scs.2020.102225

607 Landscape Architecture Foundation, 2021. LPS Case Study Brief: Cheonggyecheon Stream Restoration Project. Landscape Performance Series. https://www.landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration

608 The Guardian Weekly, 2017. Urban rivers freed up to see the light of day once more. Press Reader (15 September). https://www.pressreader.com/uk/the-guardian-weekly/20170915/282071982064370

609 Al Mashrik, 2021. Wadi Hanifa Restoration Project Infrastructure Restoration Project: for the Wadi Hanifah Zone 3. https://almashrik.com/project/wadi-hanifah-restoration-project

610 Eawag, Department Surface Waters 2022. Research and Management: River Restoration. https://www.eawag.ch/en/department/surf/main-focus/river-restoration

611 Lerner D.N., 2019. Many urban rivers are hidden underground – 'daylighting' them would bring nature back to cities. The Conversation (09 December). https://theconversation.com/many-urban-rivers-are-hidden-underground-daylighting-them-would-bring-nature-back-to-cities-128441

612 Berkeley University of California, 2022. Strawberry Creek Restoration Program. Creeks Berkeley. https://creeks.berkeley.edu/creeks-and-watersheds/strawberry-creek/strawberry-creek-restoration-program

613 United States Environmental Protection Agency, 2017. Uncovering a Long-Buried Prize in Downtown Yonkers: "Daylighting" the Saw Mill River. Brownfields Success Story. https://19january2017snapshot.epa.gov/sites/production/files/2015-09/documents/bf_ss-yonkers-saw-mill-032911.pdf

614 The World Bank, 2021. WHAT A WASTE 2.0 A Global Snapshot of Solid Waste Management to 2050: Trends in Solid Waste Management. World Bank, Washington DC. https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

615 Teta, C., and Hikwa, T., 2017. Heavy Metal Contamination of Ground Water from an Unlined Landfill in Bulawayo, Zimbabwe. Journal of Health & Pollution, 7, 18-27. https://doi.org/10.5696/2156-9614-7.15.18

616 Sullivan R., 2020. How the World's Largest Garbage Dump Evolved into a Green Oasis. The New York Times (14 August). https://www.nytimes.com/2020/08/14/nyregion/freshkills-garbage-dump-nyc.html

617 Jacobs K., 2016. How the world's largest landfill became New York's biggest new park. NY Curbed (13 September). https://ny.curbed.com/2016/9/13/12891320/freshkills-park-nyc-staten-island-engineering-design

618 Latz, T., 2018. Rehabilitation of the Hiriya Landfill, Tel Aviv. Ri-Vista. Research for landscape architecture, 16(1), 54-67. https://doi.org/10.13128/RV-22991

619 Ryan, J., 2015. Turning Trash into Treasure: Massive Trash Site 'Hiriya' Turns into Israel's Largest Eco-Park. NoCamels (19 February). https://nocamels.com/2015/02/landfill-site-hiriya-ariel-sharon-park-recycling

620 Asian Development Bank, 2018. 50 climate solutions from cities in the people's republic of China: best practices from cities taking action on climate change. Metro Manila, Philippines. http://dx.doi.org/10.22617/TCS189613-2

621 Urban Sustainability Exchange, (n.d.) Bridging social gaps with ecological restoration. USE Metropolis. https://use.metropolis.org/case-studies/bridging-social-gaps-with-ecological-restoration

622 C40 Cities, 2016. Case Study: C40 Good Practice Guides: Wuhan - Jinkou landfill restoration. Wuhan, C40 (February). https://www.c40.org/case_studies/landfill-restoration-project-to-mitigate-ghg-emissions-particularly-by-creating-an-area-for-carbon-sequestration-with-local-trees-and-plants

623 della Maggiora, J. P., 2018. Rejected landscapes. Redefining garbage towards a new waste economy. Design Thesis Report. March Urban Design Bartlett School of Architecture, University College London. http://repositorio.conicyt.cl/bitstream/handle/10533/246640/thesis%20Rejected%20Landscapes_%20Redefining%20garbage%20towards%20a%20new%20waste%20economy.pdf?sequence=1

624 Batlle i Roig Arquitectes, 2010. Landscape restoration of the Vall d'en Joan landfill site. Architizer. https://architizer.com/projects/landscape-restoration-of-the-vall-den-joan-landfill-site

625 Corradi M., 2018. Batlle i Roig: landscape restoration of the Garraf waste landfill. Floornature Architecture & Surfaces. https://www.floornature.com/batlle-i-roig-landscape-restoration-garraf-waste-landfill-14036

626 The Star, 2017. Air Hitam park is nation's first repurposed landfill. The Star (21 September). https://www.thestar.com.my/metro/focus/2017/09/21/air-hitam-park-is-nations-first-repurposed-landfill

627 UNCCD, (n.d.) The Great Green Wall Initiative https://www.unccd.int/our-work/ggwi

628 Climatekos, 2020. The Great Green Wall Implementation Status and Way Ahead to 2030. UNCCD, Bonn, pp.68. https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030

629 Climatekos, 2020. The Great Green Wall Implementation Status and Way Ahead to 2030. UNCCD, Bonn, pp.68. https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030

630 The Great Green Wall, (n.d.) Great Green Wall Accelerator. https://www.greatgreenwall.org/great-green-wall-accelerator

631 UNCCD, (n.d.) The Great green Wall Accelerator. https://www.unccd.int/actionsgreat-green-wall-initiative/great-green-wall-accelerator

632 Wetaya, R., 2021. Great Green Wall promises better lives to African farmers plagued by climate crisis. Alliance for Science (28 April). https://allianceforscience.cornell.edu/blog/2021/04/great-green-wall-promises-better-lives-to-african-farmers-plagued-by-climate-crisis

633 Morrison, J., 2016. The "Great Green Wall" Didn't Stop Desertification, but it Evolved into Something That Might. Smithsonian (23 August). https://www.smithsonianmag.com/science-nature/great-green-wall-stop-desertification-not-so-much-180960171

634 UNCCD, (n.d.) The Great Green Wall Initiative. https://www.unccd.int/actions/great-green-wall-initiative

635 Baker, A., 2019. Can a 4,815-Mile Wall of Trees Help Curb Climate Change in Africa? Time (12 September). https://time.com/5669033/great-green-wall-africa

636 Ndiaye, A., 2016. Practices of the Great Green Wall Project in the Ferlo (Senegal): Effects on Pastoral Resilience and Development. World Journal of Social Science, 3(2). https://doi.org/10.5430/wjss.v3n2p1

637 Duboz, P., Boëtsch, G., Guissé, A., Goffner, D., Peiry, J.-L., Sarr, P. and Macia, E., 2019. Reforestation and the state of health of populations in Tessekere, Senegal. Regional Environmental Change, 19(6), pp.1643–1651. https://doi.org/10.1007/s10113-019-01467-x

638 Morrison, J., 2016. The "Great Green Wall" Didn't Stop Desertification, but it Evolved into Something That Might. Smithsonian (23 August). https://www.smithsonianmag.com/science-nature/great-green-wall-stop-desertification-not-so-much-180960171/

639 Wouterse, F., and Badiane, O., 2018. Fostering transformation and growth in Niger's agricultural sector. Wageningen Academic Publishers. pp.242. https://doi.org/10.3920/978-90-8686-873-5

640 Rinaudo, T., 2007. The development of Farmer Managed Natural Regeneration. LEISA Magazine 23(2), 32. http://fmnrhub.com.au/wp-content/uploads/2013/09/Rinaudo-2007-Development-of-FMNR.pdf

641 Reij, C., and Garrity D., 2016. Scaling up farmer-managed natural regeneration in Africa to restore degraded landscapes. Biotropica 48, 834–843. https://doi.org/10.1111/btp.12390

642 UNEP, 2919. Surprising benefits of an age-old land regeneration technique. UNEP (27 March). https://www.unep.org/pt-br/node/24692

643 Reij, C., Smale, M. and Tappan, G.G., 2009. Re-greening the Sahel: farmer-led innovation in Burkina Faso and Niger. In: D.J. Spielman and R. Pandya-Lorch, eds., Millions fed: proven successes in agricultural development. Washington, D.C.: International Food Policy Research Institute, pp.53–58. https://www.ifpri.org/publication/re-greening-sahel-farmer-led-innovation-burkina-faso-and-niger

644 Carey, J., 2020. News Feature: The best strategy for using trees to improve climate and ecosystems? Go natural. Proceedings of the National Academy of Sciences, 117(9), pp.4434–4438. https://doi.org/10.1073/pnas.2000425117

645 Dodman, B., 2021. Can the "Great Green Wall" carry out Sankara's ecological, pan-African dream? France 24 (17 January). https://www.france24.com/en/africa/20210117-can-great-green-wall-carry-sankara-s-ecological-pan-african-dream

646 FAO, 2019. In Burkina Faso, the Great Green Wall is taking shape. Action Against Desertification, FAO. https://www.fao.org/in-action/action-against-desertification/news-and-multimedia/detail/ru/c/1200852

647 Sacande, M., Parfondry, M., Cicatiello, C., Scarascia-Mugnozza, G., Garba, A., Olorunfemi, P.S., Diagne, M. and Martucci, A., 2021. Socio-economic impacts derived from large scale restoration in three Great Green Wall countries. Journal of Rural Studies, 87, pp.160-168. https://doi.org/10.1016/j.jrurstud.2021.09.021

648 Climatekos, 2020. The Great Green Wall Implementation Status and Way Ahead to 2030. UNCCD, Bonn, pp.68. https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030

649 Sacande, M., Parfondry, M. and Martucci, A., 2018. Biophysical and socio-economic baselines: the starting point for Action Against Desertification. Rome, FAO. 72 pp. https://agris.fao.org/agris-search/search.do?recordID=XF2018002130

650 Climatekos, 2020. The Great Green Wall Implementation Status and Way Ahead to 2030. UNCCD, Bonn, pp.68. https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030

651 National Agency for the Great Green Wall (GGW Nigeria), 2021. National Agency for The Great Green Wall Homepage. https://ggwnigeria.gov.ng

652 FAO, 2021. Action Against Desertification: Nigeria. FAO. https://www.fao.org/in-action/action-against-desertification/countries/africa/nigeria/en

653 FAO, 2015. Regional Office for Near East and North Africa: Sudan's national action plan for the great green wall initiative finalized with FAO support. News. FAO (25 August). https://www.fao.org/neareast/news/view/en/c/326285

654 The World Bank, 2016. Promoting Sustainable Natural Resources Management in Sudan. News. The World Bank (30 March). https://www.worldbank.org/en/news/feature/2016/03/30/promoting-sustainable-natural-resources-management-in-sudan

655 Cudjoe, D.N., 2021. Disclosable Version of the ISR - Sudan Sustainable Natural Resources Management Project - P129156 - Sequence No: 14 (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/940471625080280129/Disclosable-Version-of-the-ISR-Sudan-Sustainable-Natural-Resources-Management-Project-P129156-Sequence-No-14

656 FAO, 2021. Action Against Desertification: Mauritania. FAO. https://www.fao.org/in-action/action-against-desertification/countries/africa/mauritania/en

657 The World Bank, 2021. The World Bank Mauritania Sustainable Landscape Management Project under the SAWAP (P144183): Implementation Completion and Results Report Tf A0663. Report No: ICR00005359. World Bank Group http://documents1.worldbank.org/curated/en/825511629388966252/pdf/Mauritania-Sustainable-Landscape-Management-Project.pdf

658 Climatekos, 2020. The Great Green Wall Implementation Status and Way Ahead to 2030. UNCCD, Bonn, pp.68. https://www.unccd.int/publications/great-green-wall-implementation-status-and-way-ahead-2030

659 Winterbottom, B., Reij, C. and Stirrett, G.H., 2021. Sustainable land management in the Sahel. Lessons from the Sahel and West Africa Program in Support of the Great Green Wall (SAWAP). 43 pp. The World Bank Group. https://documents1.worldbank.org/curated/en/343311608752196338/pdf/Sustainable-Land-Management-in-the-Sahel-Lessons-from-the-Sahel-and-West-Africa-Program-in-Support-of-the-Great-Green-Wall-SAWAP.pdf

660 The World Bank, 2020. Ethiopia: Sustainable Land Management Project I and II. Independent Evaluation Group, Project Performance Assessment Report 153559. Washington, DC: World Bank. https://ieg.worldbankgroup.org/sites/default/files/Data/reports/ppar_ethiopiasustainableland.pdf

661 The World Bank, 2019. The World Bank Sustainable Land Management Project (P133133): Implementation Completion and Results Report IDA-53180/TF15838/TF15868/TF15869. Report No: ICR00004449. World Bank http://documents1.worldbank.org/curated/en/470921571491240529/pdf/Ethiopia-Sustainable-Land-Management-Project.pdf

662 The World Bank, 2020. Ethiopia: Sustainable Land Management Project I and II. Independent Evaluation Group, Project Performance Assessment Report 153559. Washington, DC: World Bank https://ieg.worldbankgroup.org/sites/default/files/Data/reports/ppar_ethiopiasustainableland.pdf

663 The World Bank, 2019. The World Bank Sustainable Land Management Project (P133133): Implementation Completion and Results Report IDA-53180/TF15838/TF15868/TF15869. Report No: ICR00004449. World Bank http://documents1.worldbank.org/curated/en/470921571491240529/pdf/Ethiopia-Sustainable-Land-Management-Project.pdf

664 Winterbottom, B., Reij, C. and Stirrett, G.H., 2021. Sustainable land management in the Sahel Lessons from the Sahel and West Africa Program in Support of the Great Green Wall (SAWAP). 43 pp. The World Bank Group. https://documents1.worldbank.org/curated/en/343311608752196338/pdf/Sustainable-Land-Management-in-the-Sahel-Lessons-from-the-Sahel-and-West-Africa-Program-in-Support-of-the-Great-Green-Wall-SAWAP.pdf

665 Abraham, R., 2021. Promoting Sustainable Land Management. Eritrea Ministry of Information (20 October). https://shabait.com/2021/10/20/promoting-sustainable-land-management-2

666 UNDP Eritrea, 2018. Staff field visit: Susan visits Serejeka, advocates for documentation of best practices. UNDP Eritrea News Centre (07 September). https://www.er.undp.org/content/eritrea/en/home/presscenter/articles/2018/Serejeka.html

667 UNDP Eritrea, (n.d.) Sustainable land management practices in Serejeka curbs soil erosion, increases land productivity. UNDP. https://www.er.undp.org/content/eritrea/en/home/ourwork/environmentandenergy/successstories.html

668 Global Environmental Facility, 2017. Land of dust and dreams. GEF (05 September). https://www.thegef.org/news/land-dust-and-dreams

669 UNDP Eritrea, (n.d.) Sustainable land management practices in Serejeka curbs soil erosion, increases land productivity. UNDP. https://www.er.undp.org/content/eritrea/en/home/ourwork/environmentandenergy/successstories.html

670 UNDP Eritrea, 2018. Staff field visit: Susan visits Serejeka, advocates for documentation of best practices. UNDP Eritrea News Centre (07 September). https://www.er.undp.org/content/eritrea/en/home/presscenter/articles/2018/Serejeka.html

671 UNDP Eritrea, (n.d.) Sustainable land management practices in Serejeka curbs soil erosion, increases land productivity. https://www.er.undp.org/content/eritrea/en/home/ourwork/environmentandenergy/successstories.html

© aizal Abdul Aziz_CIFOR

PART THREE:
FRAMING THE LAND RESTORATION AGENDA

The UNCCD and its partners are setting the global agenda for land restoration – a broad spectrum of activities to avoid, reduce, and reverse land degradation while delivering co-benefits for livelihoods, climate, and biodiversity. The UNCCD's objective is to support countries with the "rehabilitation, conservation, and sustainable management of land and water resources, leading to improved living conditions". This second edition of the Global Land Outlook frames the land restoration agenda, bringing together a wide range of motivations, policy measures, financial tools, and cooperation mechanisms with on-the-ground actions being taken by diverse stakeholders.

Part One presented challenges to the sustainability of land systems and their consequences in terms of human health and wellbeing, food and water security, and climate resilience. **Part Two** illustrated the range and depth of land restoration activities already taking place and pointed to the need for more coordinated and larger-scale actions to generate more consequential benefits for people, the planet, and shared prosperity.

Part Three synthesizes the gathering momentum and sharpening focus on the potential of land restoration and demonstrates the feasibility and applicability of different pathways to recovery and resilience. **Section One** *(Partnerships and Cooperation)* describes the global partnerships and cooperation mechanisms that are essential for financing and implementing the land restoration agenda. **Section Two** *(Global Scenarios and National Commitments)* compares two global restoration scenarios with a business-as-usual baseline, in the context of the current level of ambition in national restoration commitments. **Section Three** *(Land Restoration Pathways for Recovery and Resilience)* sets out a suite of proven and flexible solutions – a rapid implementation framework to bundle human, social, and financial investments to motivate, enable, and implement actions to restore natural capital.

3.1 PARTNERSHIPS AND COOPERATION

Land is the operative link between biodiversity loss and climate change, i.e., the primary focus of interventions and partnerships to tackle these intertwined crises. Current levels of conservation and protection of the natural world are not sufficient to manage the interconnected global emergencies that humanity faces today. The existential value of nature's contribution to people calls for immediate financial support and multilateral cooperation to scale up land restoration activities, particularly in developing countries, which contain a greater distribution of intact, biodiverse, and carbon-rich ecosystems. Restoring degraded land and soil – SDG target 15.3 and achieving Land Degradation Neutrality (LDN) – provides the fertile ground on which countries and communities can take immediate and concerted action.

Governments, scientists, civil society, the United Nations, and increasingly the private sector recognize the need for proactive measures to reimagine, recharge, and restore land resources. All have come together to set land and ecosystem restoration goals and targets that commit governments and encourage businesses to transform food and energy systems as well as the global economy, its infrastructure, and the supply chains connecting producers to consumers. No country can stand alone – alliances, coalitions, partnerships, collaboration, and cooperation will be essential to build, scale, and deliver the required mix of human, social, and financial capital needed to restore natural capital and transform land use systems.

Global partnerships and cooperation will significantly increase the carbon and biodiversity benefits from restoration activities that are needed to stay within planetary boundaries.[1]

Land restoration is a shared responsibility – everyone has a role to play because everyone has a stake in the future. Governments, businesses, and communities can restore together by seeking convergence and complementarity in land and water management practices. Environmental and development priorities can be responsibly co-managed to create a healthier and more sustainable mosaic of land uses without compromising the needs and aspirations of current or future generations.[2]

United Nations

The United Nations has a unique capacity to motivate the global community, stimulate a worldwide movement, and help secure finance for land restoration at scale. With its convening power, the UN can help build the evidence base needed to assist countries in creating incentives that shift attitudes and behavior towards regenerative, climate-resilient, and nature-positive solutions. The UNEP, FAO, Rio Conventions, and many other global partners are actively shaping the land restoration agenda, using a range of strategies and approaches that can be tailored for local contexts and implemented at multiple scales.[3]

Land restoration provides a unique entry point for the application of rights-based approaches to natural resource management to help ensure an adequate standard of living. These approaches are considerably more effective when explicitly linked to existing environmental commitments in international treaties and agreements. For example:

- In 2019, the UNCCD adopted a decision which "invites Parties to ensure that measures to combat desertification, land degradation, and drought are carried out in a non-discriminatory and participatory way so that they promote equal tenure rights and access to land for all, in particular vulnerable and marginal groups".[4]
- In 2021, the UN Human Rights Council adopted a resolution that "calls upon all States to conserve, protect and restore healthy ecosystems and biodiversity and to ensure their sustainable management and use by applying a human rights-based approach that emphasizes participation, inclusion, transparency, and accountability in natural resource management".[5]

The Sustainable Development Goals (including LDN targets),[6] Paris Agreement,[7] and post-2020 global biodiversity framework provide countries, corporations, and communities with sufficiently ambitious goals and clear targets, and most importantly a blueprint for action at all levels.[8] [9] When taken together, these agreed upon strategies and commitments will underpin the success of the land restoration agenda. Evidence from around the world suggests that many development objectives would benefit from land restoration, both in terms of process and outcomes.[10] Furthermore, the UN General Assembly has affirmed that combating desertification, land degradation, and drought – and achieving LDN – is an effective pathway to accelerate progress towards achieving multiple Sustainable Development Goals by 2030.[11]

The UN Decade on Ecosystem Restoration is an open invitation to governments, businesses, and civil society, in partnership with indigenous peoples and local communities, to participate in a restorative process to improve human, economic, and planetary health.

As the UN Decade on Ecosystem Restoration (2021-2030) gets underway, now is the time to reposition investments in human, social, and natural capital for short-term recovery and to enable long-term planning and implementation. The Decade is galvanizing indigenous peoples and local communities, governments, the private sector, and civil society as part of a global movement to undertake all types of restoration, across all scales, marshalling all possible resources. This powerful 10-year drive for ecosystem restoration aims to transform land-based commodity production systems to meet the demands of the 21st century while eradicating poverty, hunger, and malnutrition.[12] Just as COVID-19 vaccines were developed, tested, and rolled out at unprecedented speed and scale, so too must land restoration and other nature-based solutions to prevent further environmental decline and ensure a healthy and prosperous future.

Leadership from the UN, G20, Bonn Challenge, and other global and regional initiatives to reverse land degradation is also helping to raise the level of ambition. However, it is individual country policies and efforts that will drive action on the ground through a combination of measures and customized land restoration pathways that build on existing and emerging capacities to innovate and remain competitive. In fulfilling their restoration commitments, countries should also address critical governance and equity issues, especially when expanding protected areas or undertaking restoration activities that may disenfranchise vulnerable communities.

Rio Conventions

The Glasgow Leaders Declaration on Forests and Land Use asserted for the first time the importance of leveraging multiple UN processes. Over 130 countries promised to reaffirm their respective individual and collective commitments under the three Rio Conventions – on Desertification (UNCCD), Biological Diversity (CBD), and Climate Change (UNFCCC). This landmark declaration announced at UNFCCC COP26 is supported by unprecedented corporate and donor pledges and includes assurances of financing and more secure land tenure and forest rights for indigenous peoples and local communities. It also includes commitments to facilitate trade and development policies that avoid deforestation and land degradation, especially regarding internationally traded agricultural commodities, such as beef, soy, palm oil, and timber.[13]

The Rio Conventions are multilateral environmental agreements that emerged from the 1992 Earth Summit. These conventions are now strategically positioned to activate the land restoration agenda.[14] Their mandates address interdependent issues related to the sustainability of Earth systems. At the global level, the institutions and processes of the Rio Conventions are almost identical in their decision-making and subsidiary bodies – and in their modes of stakeholder engagement. Each convention sets goals and targets, with their country Parties developing action plans to fund and implement them at the national level. The conservation, sustainable use and management, and restoration of land resources are vital to the success of these national action plans.

The efficiency gains of joint land, climate, and biodiversity prioritization underscore the mutual benefits that arise from bridging the aims of the three Rio Conventions rather than pursuing their objectives in isolation.[15]

UNCCD – is focused on the rehabilitation, conservation, and sustainable management of land and water resources, leading to improved living conditions. It specifically addresses the challenges of desertification, land degradation, and drought, primarily in dryland regions where some of the most vulnerable communities live and work. Sustainable Development Goal Target 15.3, for which the UNCCD is the custodian, includes restoring degraded land and soil while striving to achieve LDN or no net loss in land-based natural capital.[16] The UNCCD directly supports countries through capacity building and resource mobilization for a broad range of regenerative measures. To date, more than 130 countries have committed to, and more than 80 have already, set their national LDN targets.[17]

CBD – is focused on the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources. In 2010, it set an ambitious target of restoring 15% of degraded ecosystems by 2020. While the target was not met, ambitious restoration projects and programs are now under way or proposed in many regions, with the potential to deliver significant gains in ecosystem resilience and the preservation of carbon stocks.[18] The post-2020 global biodiversity framework – expected to be adopted in late 2022 – will aim to expand protected and conservation areas and provide a further boost to land restoration initiatives.

UNFCCC – is focused on the stabilization of greenhouse gas concentrations in the atmosphere to prevent dangerous human interference with the climate system. The Paris Agreement of 2015 aims to keep average global warming increases to under 1.5°C by reducing emissions to net zero by the second half of this century. Nationally determined contributions (NDCs) are the main vehicle for country commitments to mitigate greenhouse gas emissions and adapt to the impacts of climate change.

Bringing together national action plans currently siloed under the UNCCD, CBD, and UNFCCC frameworks represents an immediate opportunity to align targets and commitments to implement land restoration, realize multiple benefits, and maximize returns on investment.

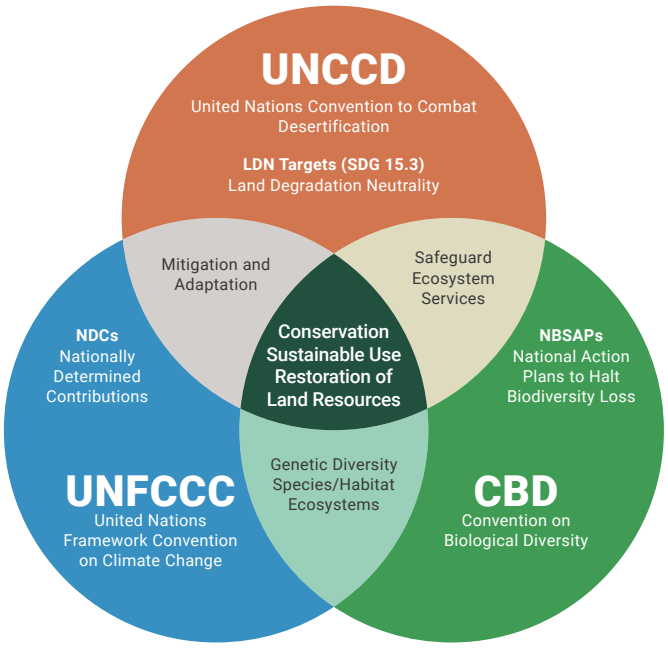
To begin, countries could explore the ways and means to merge their national action plans (e.g., NDC, LDN, NBSAP) into a single unified strategy and implementation plan. By mapping overlapping challenges and opportunities, countries can achieve economies of scale to meet the objectives of the Rio Conventions while advancing national development priorities. For example, if climate change is the overriding priority for a country, restoration commitments and response measures under other conventions and related processes (e.g., Ramsar Convention on Wetlands) could be allied and integrated into mitigation and adaptation objectives. This increased level of coherence would unlock the potential of sectoral and departmental coordination, create a pipeline of investment-ready projects and programs, and engage the private sector and civil society to cost-effectively achieve mutual benefits through land restoration.

Bonn Challenge and Forest Landscape Restoration

The Bonn Challenge was launched by the German government and the International Union for the Conservation of Nature (IUCN) in 2011. It is a voluntary, non-binding, global initiative to advance environmental sustainability through forest

© harold-wainwright-unsplash

FIGURE 3.1 Land restoration and the Rio Conventions



landscape restoration. Most of the commitments are made by national governments or regional groups, with some private companies and other non-state actors that have also made pledges. The goal is to restore 150 million hectares of the world's deforested and degraded lands by 2020, and a total of 350 million hectares by 2030.[19]

In 2020, the World Economic Forum launched a global initiative to grow, restore, and conserve one trillion trees around the world. The initiative aims to unite governments, non-governmental organizations, businesses, and individuals in mass-scale nature restoration.[20] Like the Bonn Challenge, the initiative has many regional offshoots, such as the One Trillion Trees Sahel Coalition, which strive to enable innovation and 'ecopreneurship' using private enterprise approaches to solve environmental problems.[21]

G20 Initiative on Reducing Land Degradation

The Global Initiative on Reducing Land Degradation and Enhancing Conservation of Terrestrial Habitats was launched in November 2020 by G20 leaders in Riyadh, Saudi Arabia. The ambition is to reduce land degradation by 50% by 2040.[22] Building on existing efforts, the initiative aims to enhance collaboration by focusing on three interrelated objectives:

- Conserving land and halting habitat loss, fragmentation, and land degradation
- Promoting integrated, sustainable, and resilient land and landscape management
- Restoring degraded land and habitat

The initiative also aims to enhance collaboration among G20 members and non-member countries to support the implementation of current commitments for conservation, sustainable land management, and restoration, as well as encourage additional voluntary commitments.

Beyond Planting Trees

Restoring forests and planting trees has become a powerful strategy driving global efforts and attracting much-needed funding for land restoration.[23] However, not all land nor all species are suitable for this type of restoration. Grasslands and savannas are productive, biodiverse ecosystems that support the livelihoods of millions of people. They match forests both in their global extent and in their need for protection and restoration. Equally important are wetlands, which are in long-term decline, averaging losses at three times the rate of global forest loss in recent decades. Sustaining their capacity to absorb and store carbon is seen as key to a climate-resilient future.[24]

The UN Decade on Ecosystem Restoration calls for a balanced response, addressing all ecosystems and their connectivity within a healthy landscape mosaic.[25] It is estimated that nearly half the land pledged for restoration under the Bonn Challenge is earmarked for monoculture plantations, mostly fast-growing exotic species.[26] These afforestation commitments target large areas in Africa, Asia, and South America, which are or were historically drylands, rangelands, savannas, and grasslands.[27] If implemented, these tree plantings would only provide a fraction of the ecosystem services that naturally regenerating forests produce, including significantly less carbon storage, groundwater recharge, and wildlife habitat.[28]

3.2 GLOBAL SCENARIOS AND NATIONAL COMMITMENTS

The PBL Netherlands Environmental Assessment Agency has provided a first approximation of the global and regional potential of land restoration using a novel scenario analysis.[29] These scenarios can inform strategic planning and guide robust actions in different socio-environmental contexts.[30] They provide a glimpse into different futures, examining biophysical actions and impacts, and making quantitative assessments of what may unfold. The scenarios reveal the effects of land restoration for natural areas, biodiversity, soil organic carbon, agricultural yields, water regulation, and carbon storage. Current national restoration commitments are clearly inadequate to realize the promise of the restoration scenarios.

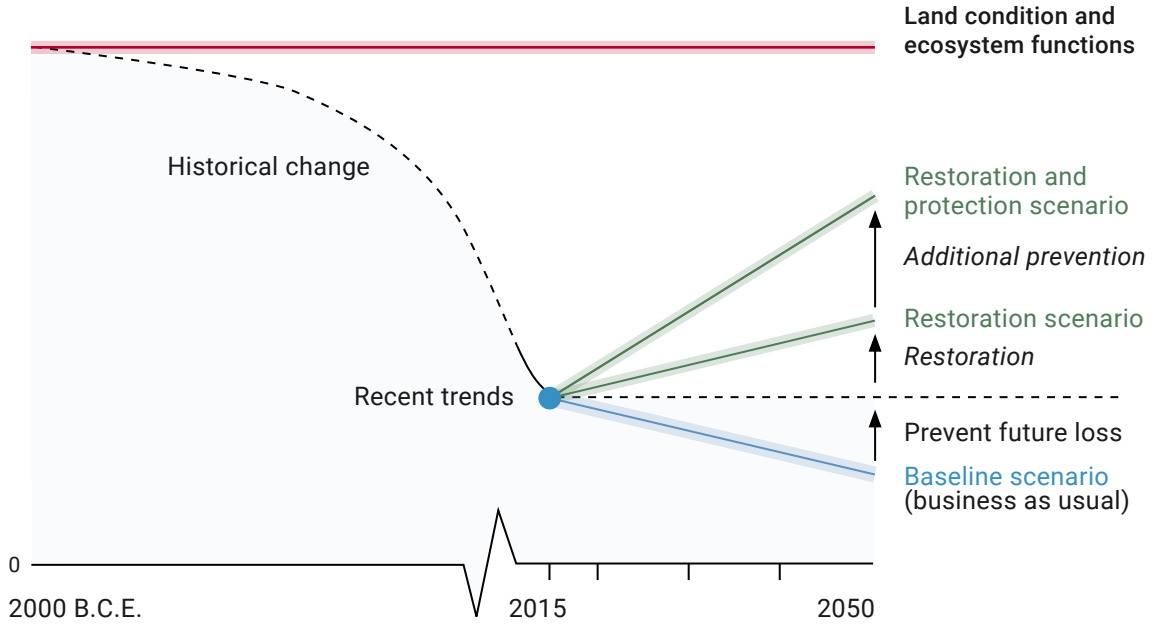
3.2.1 Looking into the Future

Three scenarios to 2050 provide views on the extent and risks if land degradation trends continue and estimate the potential for land restoration at different scales:

- **Baseline.** This is business as usual, where current trends in land and natural resource degradation are projected to continue through to 2050
- **Restoration.** This assumes the restoration of around 50 million square kilometers (35% of the global land area) using measures such as agroforestry, grazing management, and assisted natural regeneration
- **Restoration and Protection.** In addition to the same restoration measures, natural areas important for specific ecosystem functions are protected from land conversion

The scenarios provide an estimate of the potential of land restoration to mitigate and adapt to climate change as well as provide food, materials, and energy. They are constructed using a set of indicators that measure land conditions – such as land use change, soil organic carbon, primary productivity, and biodiversity – which influence agriculture, water regulation, and carbon stocks. Other contemporary scenario analyses explicitly consider factors such as environmental governance, land distribution, and access to resources.[31] [32]

FIGURE 3.2 Three scenarios for future land health



Source: PBL, 2021.

Baseline Scenario

The baseline scenario assumes that no additional efforts are made to protect or restore land resources. It is constructed using agro-economic, land use, and vegetation modeling tools to project agricultural, land use, and food system dynamics to 2050. Estimates of current trends in land degradation are based on satellite observations of the normalized difference vegetation index (NDVI) between 2001 and 2018.

The baseline scenario projects a continued global decline in land conditions and most ecosystem functions while demands for food, feed, fiber, and bioenergy continue to rise. Current systems of land management and climate change continue to cause widespread soil erosion, declining fertility and growth in yields, and the further loss of natural areas due to expanding agriculture. By 2050:

- **16 million square kilometers show continued land degradation (the size of South America)**
  A persistent, long-term decline in vegetative productivity is observed for 12-14% of agricultural, pasture and grazing land, and natural areas – with sub-Saharan Africa worst affected.
- **An additional 69 gigatonnes of carbon is emitted from 2015 to 2050 due to land use change and soil degradation**
  This represents 17% of current annual greenhouse gas emissions: soil organic carbon (32 gigatonnes), vegetation (27 gigatonnes), peatland degradation/conversion (10 gigatonnes).
- **A slowing in the growth of agricultural yields**
  While agricultural yields are still projected to rise in all regions, land degradation will curb increases, especially in the Middle East, North Africa, sub-Saharan Africa, and Latin America. The loss of soil organic carbon and the soil's ability to hold water and nutrients, such as phosphorus or nitrogen, will be primarily responsible for this slowing, while the associated risks of drought and water scarcity are expected to increase.
- **Nature and biodiversity will continue to suffer**
  The demand for food, expected to rise by 45% between 2015 and 2050, will have to be met by further intensification and expansion of agricultural land, resulting in the further loss of 3 million square kilometers of natural areas (the size of India), mainly in sub-Saharan Africa and Latin America.

Restoration Scenario

The restoration scenario assumes that land restoration is done on a massive scale – across a potential 50 million square kilometers (5 billion hectares). The restoration measures included in this scenario are:

- Conservation agriculture (low- or no-till farming)
- Agroforestry and silvopasture (combining trees with crops, livestock, or both)
- Improved grazing management and grassland rehabilitation
- Forest plantations
- Assisted natural regeneration
- Cross-slope barriers to prevent soil erosion

The restoration scenario applies these measures to roughly 16 million square kilometers of cropland, 22 million of grazing land, and 14 million of natural areas. Sub-Saharan Africa and Latin America are estimated to have the largest areas with the potential for land restoration. When compared to the baseline scenario, restoration means by 2050:

- **Crop yields increase by 5-10% in most developing countries compared to the baseline**
  Improved soil health leads to higher crop yields, with the largest gains in the Middle East and North Africa, Latin America, and sub-Saharan Africa, limiting food price increases. Soil water holding capacity would increase by 4% in rainfed croplands.
- **Carbon stocks rise by a net 17 gigatonnes between 2015 and 2050 due to gains in soil carbon and reduced emissions**
  This is the balance of a net increase in soil organic carbon, increased carbon in agroforestry, and a continued loss of vegetation carbon due to land conversion. It does not account for the potential carbon storage gains above ground from forest restoration. Soil carbon stocks would be 55 gigatonnes larger in 2050 compared to the baseline, with the largest gains in Russia, Eastern Europe, Central Asia, and Latin America, while the biggest losses would be avoided in sub-Saharan Africa.

- **Slowed biodiversity decline and loss of natural areas**
  Globally, the extent of natural areas continues to decline due to the expansion of agricultural and urban areas, except in Latin America where natural areas are projected to increase by 3%. Biodiversity would continue to decline, but not as quickly, with 11% of biodiversity loss averted.

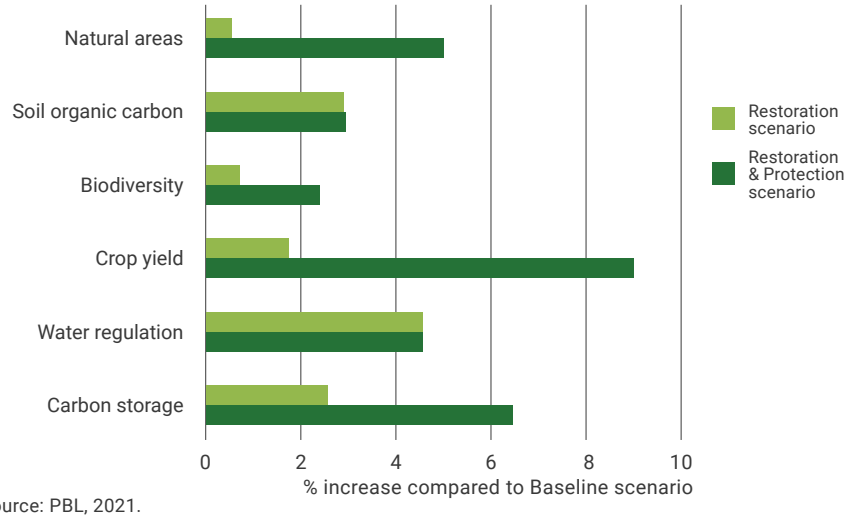
Restoration and Protection Scenario

This scenario includes restoration measures, augmented with protection measures expanded to cover close to half of the Earth's land surface by 2050 – a threefold increase on the current coverage. These protected areas are important for biodiversity, water regulation, conservation of soil and carbon stocks, and provision of critical ecosystem functions. However, significantly increasing the extent of protected land would limit the expansion of agriculture. Under this constraint, current yields would have to be 9% higher by 2050 than in the baseline scenario to meet expected demand. Nonetheless, food prices are projected to increase, particularly in South and Southeast Asia, where a scarcity of agricultural land is already impacting food security.

Under this scenario, most of the new protected areas would have to be in sub-Saharan Africa and Latin America. When compared to the baseline, the restoration and protection scenario means by 2050:

- **An additional 4 million square kilometers of natural areas (the size of India and Pakistan)**
  With the largest gains expected in South and Southeast Asia and Latin America, protected areas would prevent land degradation by logging, burning, draining, or conversion. While biodiversity would continue to decline, about a third of the loss projected in the baseline would be prevented under restoration and protection measures.
- **An additional 83 gigatonnes are stored compared to the baseline**
  Avoided emission and increased carbon storage would be equivalent to more than seven years of total current global emissions.

FIGURE 3.3 Global effects of restoration scenarios



Source: PBL, 2021.

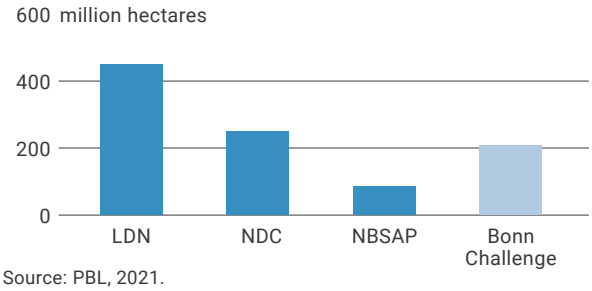
Translating Commitments into Action

The stark implications for the human condition and that of the planet suggested by the baseline scenario mean that decisive action – at all levels, from all actors – is vital to deliver the promise of the restoration and protection scenario. However, the mismatch between the scale of interventions in the scenarios and those in current commitments is a sobering reality check on efforts to ensure human and planetary sustainability. It is individual country policies and community initiatives that will drive meaningful action on the ground. Governments should use all tools available and strive to link land restoration and protection measures with profound changes in investment and consumption patterns to maximize their benefits for society and the planet.

3.2.2 National Restoration Commitments

Ambitious land restoration targets must be backed by clear action plans and sustained financing. To date, over 115 countries have committed to restore close to 10 million square kilometers of degraded land. These pledges are included in national action plans under the Rio Conventions, the Bonn Challenge, and other global and regional initiatives. Almost half of all restoration commitments are in sub-Saharan Africa, while Asia and Latin America have also made significant pledges relative to their land area.[33]

FIGURE 3.4 Global restoration commitments



Source: PBL, 2021.

The 10 million square kilometers – one billion hectares – pledged is the size of Canada but still insufficient to realize a nature-positive and climate-resilient future. The commitments themselves are divided almost equally between restoring native ecosystems and conserving intact ones, and the sustainable management and rehabilitation of agricultural and production lands. They cover roughly one-fifth of global cropland, one-tenth of all forest areas, and a small share of pastureland.[34]

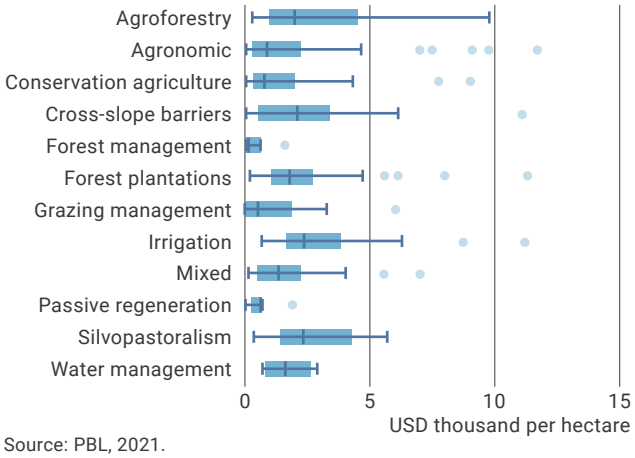
Implementing current restoration commitments over the next 10 years are estimated to cost between USD 305 billion and 1.7 trillion.[35] This is significant but far less than the amount of subsidies currently provided to the agriculture and fossil fuel industries. The wide range in costs is due to the diversity of locations and practices,

Countries that are disproportionately responsible for the climate, biodiversity, and environmental crises must do more to support developing countries as they restore their land resources and make these activities central to building healthier and more resilient societies.[36]

but also reflects of limited data availability. For example, engineering measures, such as terracing and irrigation, can be costly. Agroforestry and regenerative agriculture are cheaper, but vary depending on the level of intensity and effort. The costs of forest and grazing management, including natural regeneration, are relatively low.

It is unrealistic and unfair to expect most developing countries to be able to cover all these costs. Extra-budgetary support will be needed in the form of investments, development aid (for trade), debt relief, or other financial instruments. In some cases, restoration initiatives are adopting territorial and landscape approaches to better leverage private financing. This allows diverse groups of stakeholders to form networks and institutions that pool resources, aggregate projects, and share costs, making these approaches more attractive to multiple donors and funding sources.[37]

FIGURE 3.5 Cost range per restoration measure



Source: PBL, 2021.

3.3. LAND RESTORATION PATHWAYS FOR RECOVERY AND RESILIENCE

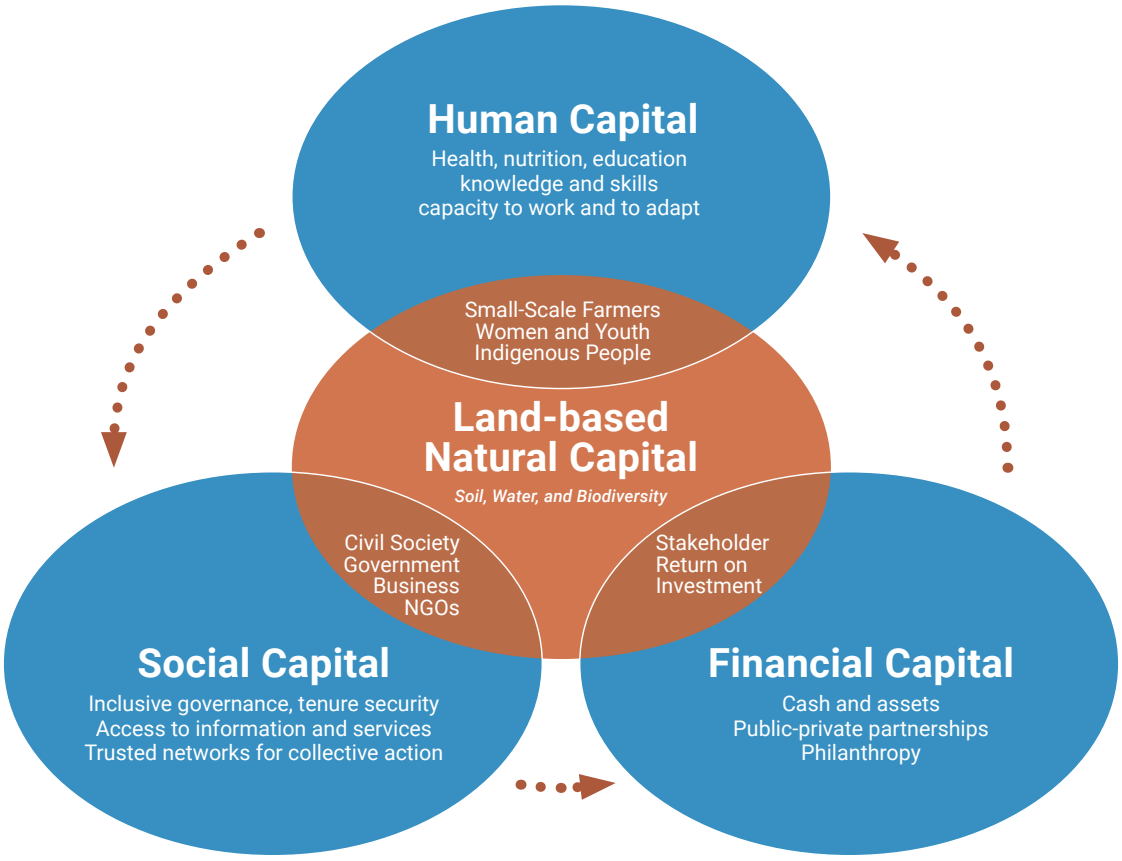
The aim of land restoration is to preserve and replenish land-based natural capital – the soil, water, and biodiversity that sustains all life on Earth. Sustainable land and water management practices not only regenerate these vital resources, but enhance the capacity of human communities and ecosystems to prepare for, cope with, and recover from natural disasters and human-induced environmental crises that are becoming more frequent and intense. Land restoration is a powerful and flexible solution that can also promote landscape and biocultural renaissance through the revival of traditional and local community land governance and management practices.

Restoring natural capital depends on the wise use of other forms of capital, such as human, social, and financial capital. Much as an investor uses financial capital to make profits, regenerating a forest or improving soil health offers returns in the form of a future supply of timber or food. But there are many pathways with the potential to bundle different forms of capital to restore natural capital and realize a more equitable and sustainable balance between economic, social, and environmental objectives.

Our planet, the lives of all its inhabitants, and our future prosperity depend on the conservation, wise use, sustainable management, and restoration of land resources.

Our challenge is to motivate, enable, and implement regenerative land use practices for both short-term recovery and long-term resilience.

FIGURE 3.6 Harnessing forms of capital for land restoration



3.3.1 Realigning Financial Capital

Globally, governments have already committed to restore 10 million square kilometers of farms, forests, and pasture through a variety of pledges – almost half come under the voluntary national LDN targets set by UNCCD country Parties. In total, these pledges are equivalent to an area greater than the size of the United States or China. The costs of land restoration are likely to be prohibitive for most developing countries without international financial support and cost-sharing mechanisms.[38] A variety of traditional and emerging funding sources are now available to countries, in addition to domestic measures that reallocate or repurpose government budgets and development assistance for synergistic land restoration activities.

Integrated financial solutions that address national priorities and commitments related to climate change, disaster risk reduction, and land restoration are a fundamental governance challenge for the next decade.[39]

Global Environment Facility (GEF): Since 2006, the GEF has invested over USD 1 billion in its land degradation focal area. This includes funding for nearly 200 projects and programs that encourage the use of sustainable land management practices. These projects have covered over 1.4 million square kilometers (equivalent to France, Spain, and Germany combined) and benefited more than 80 million smallholders, significantly expanding land restoration activities and contributing to other GEF focal areas, such as biodiversity and climate change.[40] Under the 7th GEF replenishment, new Impact Programs on Food Systems, Land Use and Restoration, Sustainable Forest Management, and Sustainable Cities were developed to tackle the drivers of environmental degradation and support systemic change in land use and management practices.[41] The 8th GEF replenishment is expected to continue focusing on addressing degradation in an integrated manner, potentially expanding the availability of resources for ecosystem restoration activities.[42]

World Bank Group: In the five years to 2020, nearly six million people benefited from World Bank restoration projects, including 1.1 million women and 225,000 indigenous peoples. Almost one million land users adopted sustainable landscape management, over an area of 380,000 square kilometers (equal to the land area of Japan). Additionally, over 700,000 square kilometers gained enhanced biodiversity protection and about 6,000 square kilometers were restored or afforested to reduce or avoid an estimated 17 million tonnes of carbon emissions. An estimated 245,000 people gained forest use or ownership rights through the projects, including 61,000 women, and vulnerable peoples' participation in decision making processes increased twentyfold.[43]

Financial Commitments Accompanying the Leaders Declaration on Forests and Land Use

At UNFCCC COP26 in November 2021, more than 130 world leaders committed to work collectively to halt and reverse forest loss and land degradation by 2030, while delivering sustainable development and promoting inclusive rural transformation.[44] Funding will be provided to developing nations as a priority, supporting projects to restore land degraded by land use change due to agri-food and other commercial activities as well as floods, drought, and wildfires.

The commitment includes over USD 19 billion in public and private funds to support regenerative actions,[45] with 14 country and philanthropic donors pledging at least USD 1.7 billion between 2021 and 2025 to advance indigenous peoples and local communities' forest tenure rights and support their role as guardians of forests and nature.[46] The commitment also includes a pledge by 12 country and philanthropic donors of at least USD 1.5 billion to protect the forests of the Congo Basin;[47] an announcement by the Bezos Earth Fund of an additional USD 1 billion to accelerate landscape restoration in the Great Green Wall countries of Africa;[48] and a promise by CEOs from more than 30 financial institutions controlling more than USD 8.7 trillion in global assets to eliminate investment in activities linked to deforestation.[49]

Innovative Finance for Land Restoration

While the investment climate is not yet fully mature, it is well accepted that private sector capital and blended finance will be needed to achieve many land restoration goals. To best ensure the full delivery of social, economic, and environmental returns, innovative financial arrangements are being structured to match investors to different types of restoration projects and programmes.[50]

Land Degradation Neutrality (LDN) Fund: The UNCCD spearheaded the establishment of the LDN Fund, a path-breaking example of how the public and private sector can invest together in nature-positive solutions to enhance livelihoods in developing countries. Investing in land restoration is not just about improving environmental health or safeguarding ecosystem services. It is also a quick way to create jobs, improve livelihood opportunities, and promote equitable and sustainable development in places that have been historically poorly served by private investments. These investments can help ensure that COVID-19 recovery efforts support green jobs and sustainable businesses for the billions of people who depend on land resources for their livelihoods.[51]

LDN Fund Technical Assistance Facility (TAF)

The LDN TAF provides resources and technical assistance to project developers in developing and emerging economies. It is grounded in a common platform that promotes strong social and environmental safeguards, enhances the rights of people living and working in project areas, and links land restoration to the creation of meaningful jobs and livelihoods. The TAF reinforces the credibility of the investment process to ensure that strong, verifiable results are obtained from the use of LDN Fund capital.[52]

Urapi Sustainable Land Use is an innovative agroforestry program working in Peru, Colombia, and across Latin America, designed and operated by Ecotierra.[53] It supports the development of mid-size cooperatives by restoring degraded land, implementing agroforestry systems, constructing processing units to increase added value, and generating carbon credits. With an investment from the UNCCD's LDN Fund in 2018, the project produced results with significant replicability and scalability potential: in Peru, 3,000 small-scale producers now benefit from 83 square kilometers of restored land and 2,000 square kilometers of conserved forests; in Colombia, 45 square kilometers of land and 700 square kilometers of forest were conserved or restored, enabling carbon sequestration equivalent to 1.3 million tonnes of carbon dioxide.[54] [55]

FIGURE 3.7 Creating a new regenerative land asset class

Source: IDH/Mirova

Restoration Seed Capital Facility: With an initial capitalization of USD 28 million, the facility was launched in October 2020 to boost the contribution of private finance to forest restoration. The aim is to help fund managers set up dedicated investments for land restoration projects in developing countries, contributing to efforts to meet the objectives of the Sustainable Development Goals and the Rio Conventions, in particular the Paris Agreement, LDN targets, and the post-2020 biodiversity targets. The facility will require cooperating partners to bear at least 50% of eligible costs to guarantee that its funding is spent on the most promising projects.[56]

Land Accelerator: Through online and in-person bootcamps and personalized mentorship, this World Resources Institute program allows entrepreneurs to pitch concepts to impact investors and thus provides a cost-effective approach to restore and develop rural areas around the world. To date, 56 entrepreneurs from 23 countries have participated, with more than 2,700 jobs created. An estimated 120,000 farmers have been assisted, resulting in more than 1,000 square kilometers of land restored.[57] In partnership with the Land Accelerator, a Rural Prosperity Bond provides loans to SMEs working to restore land across Africa, South Asia, and Latin America by delivering credit and tailored capacity building to enterprises: discounted interest rates incentivize SMEs to boost their social and environmental impact by working closely with smallholders.[58]

Restore Fund: This fund makes investments in forestry projects to sequester carbon while seeking to generate a competitive financial return for investors. Launched by Conservation International and Goldman Sachs, Apple's USD 200 million fund aims to remove at least one million tonnes of CO_2 annually from the atmosphere – equivalent to the annual fuel used by over 200,000 cars – and demonstrate a viable financial model that can act as a catalyst to scale up investment in forest restoration. The fund will use robust international standards developed by recognized organizations, such as Verra, the IPCC, and UNFCCC to prioritize investments in working forests to improve biodiversity by creating buffer zones and natural set-asides.[59]

Ecosystem Restoration Fund: Launched by BNP Paribas Asset Management in 2021, this fund is expected to invest in 40-60 holdings selected from 1,000 global companies focused on ecosystem restoration. The fund will focus on aquatic ecosystems (e.g., water pollution control, water treatment and sustainable packaging, aquaculture, efficient irrigation systems, and flood control solutions); terrestrial ecosystems (e.g., technologies relating to alternative protein, sustainable agriculture, forestry, and plantations); and urban ecosystems (e.g., environmental services, green buildings, recycling, waste management, and alternative transport).[60]

Food Systems, Land Use and Restoration (FOLUR) Impact Program: This program is structured around a global platform and 27 country projects, which aims to transform the global food and land use systems by restoring degraded landscapes and promoting sustainable land management practices. With a commitment of USD 307 million from the GEF and additional co-financing, FOLUR promotes sustainable integrated landscape management and more efficient food value chains at scale. It specifically targets large production landscapes for eight commodities: beef, cocoa, maize, coffee, palm oil, rice, soy, and wheat.[61]

Environmental, Social and Governance (ESG) Standards

Investments in the land use sector come from public and private sources, and both have the potential to incentivize land restoration activities. While governments can channel financial flows through a range of mechanisms, they can also pull levers to change tax incentives around private investments, encourage the adoption of ESG standards, and implement financial de-risking policies. These strategies would boost the amount of private sector finance for restoring natural capital.[62] [63] A range of ESG standards and reporting protocols are used by firms and investment funds to screen investments according to three pillars:

- **An environmental pillar** interrogates how companies perform as nature stewards, focusing on the environmental impact, carbon footprint, and resource intensity of their investments.
- **A social pillar** evaluates companies' relationships with employees, suppliers, customers, and the communities in which it operates, including labor relations, diversity, and inclusion.
- **A governance pillar** focuses on internal governance systems and practices, such as decision-making on executive remuneration, shareholder rights, and stakeholder interactions.

The rapid growth of ESG-oriented investing in recent years is due to heightened societal, governmental, and consumer attention on issues of sustainability and equity.[64] Investors and executives understand that adherence to ESG standards can both safeguard a firm's long-term success,[65] and align it with the Sustainable Development Goals.[66] ESG has great potential to attract significant financing for restoration activities, particularly those that increase the impact, security, and diversity of investments.[67]

However, the range of approaches, claims, and categorizations of ESG investment tools can make it difficult for investors to find products that match their values.

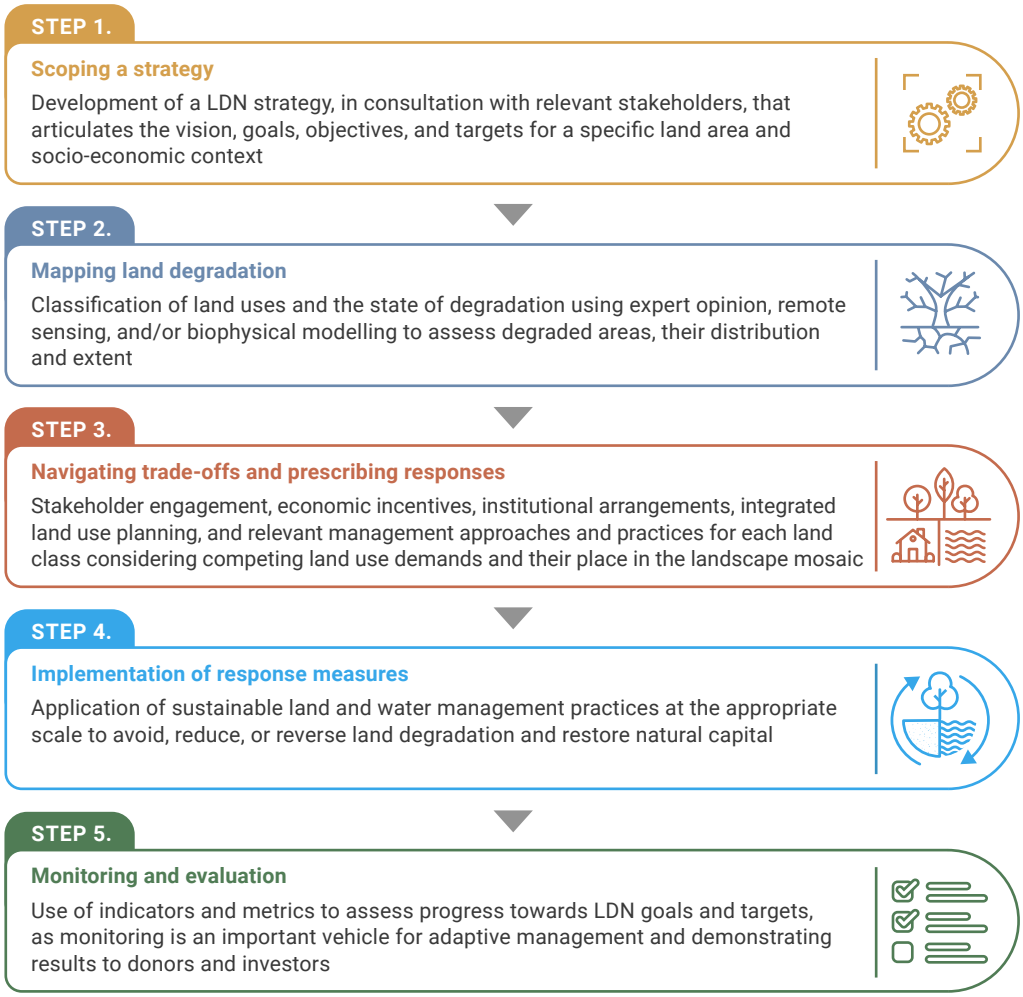
At the start of 2020, global ESG assets were valued at USD 35 trillion. While this amount was 15% higher than two years earlier, these investments need increased transparency and better guidance to deliver demonstrable environmental or climate benefits.[68] [69]

Demonstrating Investment Returns through Effective Monitoring

Participatory monitoring and evaluation are critical to adapt management practices when needed and equally important to demonstrate the returns on restoration investments. Effective monitoring helps communities, governments, companies, NGOs, and donors understand where restoration interventions are having a real impact on emissions and carbon storage, biodiversity conservation, and peoples' livelihoods. Those doing the hard work of restoration learn where their successes can be replicated and allow them to pivot quickly away from failures. For donors and funders, monitoring reveals where their investments are transforming lives and livelihoods.[70] Many stakeholders involved in restoration activities are interested in monitoring progress – ranging from scientists[71] to governments,[72] donors,[73] businesses,[74] and activists.[75]

Restoration monitoring can be multi-dimensional and multi-level, from the global to the local. International principles for monitoring land restoration stress the importance of baseline and indicator development to measure progress; site assessment and the identification of reference land or ecosystem conditions; the need to consider the costs and benefits of different restoration approaches (e.g., active versus passive regeneration); and the development of evaluation, reporting, and auditing criteria. As different stakeholders naturally emphasize different aspects of restoration outcomes, monitoring progress on the ground can be a complex task.[76]

FIGURE 3.8 Steps for designing and implementing LDN initiatives



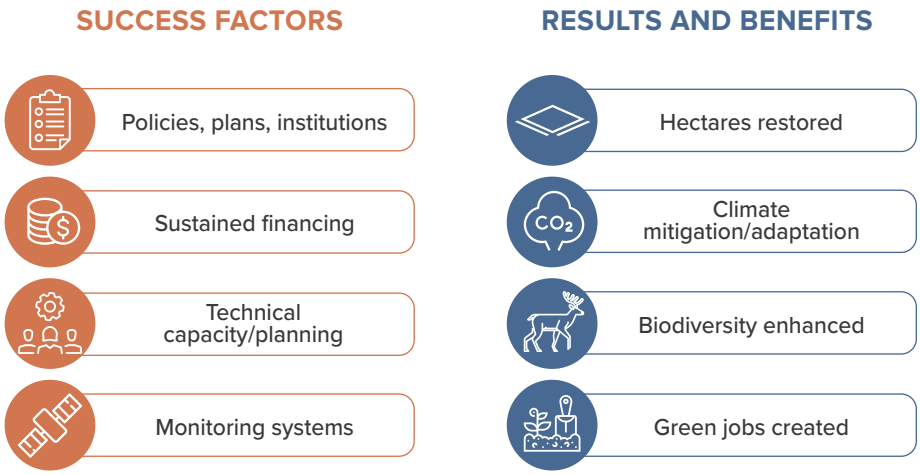
Emerging Tools for Monitoring Land Restoration

© NASA

Transparency propels action. Artificial intelligence has proven to be effective for the planning and assessment of restoration in terrestrial ecosystems.[77] Rapid advances in geospatial monitoring, including Earth observations, can provide a powerful and near real-time framework for the robust and transparent monitoring and evaluation of projects in order to build investor trust and confidence.[78] Frequent, high-resolution imagery is becoming cheaper and more accessible, allowing more restoration initiatives to use these tools to verify project results. With rapid increases in computational power (e.g., high-speed data transfers, denser coverage from higher resolution satellites) and open-source and collaborative science, new levels of data transparency are available to enable more effective restoration. By demonstrating results in an independent and comparative manner, public and private sector actors are likely to feel more comfortable investing larger sums in land restoration as a part of their efforts to achieve net-zero, nature-positive goals.

The **1t.org Corporate Alliance** advocates for credible corporate investment and offers companies the chance to pledge to conserve, restore, and grow forests, while learning from the experience of their peers.[79] **WRI's TerraMatch platform** matches potential funders to implementing partners, helping facilitate partnerships and monitor project progress.[80] **Restor**, developed by ETH Zurich, connects global and site levels by offering a suite of easy-to-use geospatial tools to plan restoration interventions and track progress over time.[81] The **IUCN Restoration Barometer** works with national and sub-national governments and private sector actors who have made restoration commitments to track progress on the key enabling and success factors as well as on biodiversity values, carbon sequestration, and economic targets.[82] The **Task Force on Monitoring for the UN Decade on Ecosystem Restoration** is facilitated by FAO and involves 100 organizations as part of an overarching coordination platform, Framework for Ecosystem Restoration Monitoring, to improve data access and transparency.[83] The **Global Restoration Observatory**, coordinated by Climate Focus, brings together restoration experts and practitioners to coordinate initiatives, facilitate data sharing, and create links between restoration monitoring platforms.[84] Together, these and other efforts are driving increased collaboration among experts and restoration initiatives to make monitoring more effective, efficient, and practical for communities, companies, governments, and donors.

FIGURE 3.9 IUCN Restoration Barometer



Source: IUCN

3.3.2 Building Human and Social Capital

Human capital encompasses people's health, nutrition, education, knowledge, and skills, and their capacity to work and to adapt.[85] When coupled with rights (secure tenure), rewards (financial incentives), and a sense of responsibility (shared vision), human capital can motivate and enable stakeholders to effectively cooperate and implement land restoration activities.

Social capital encompasses the norms of trust and reciprocity within a community, the institutional relationships that enable individuals to network and act collectively to ensure a flow of benefits.[86] Social norms regulate interactions that influence land restoration decisions, while trust and reciprocity sustains community involvement, avoids/reduces potential harm, and increases tolerance of uncertainty.[87]

Human and social capital form an integral part of the enabling environment and help maximize the impact of financial capital for land restoration activities. Restoring natural capital is place-based, embedded in a local context, and its effectiveness is largely dependent on the sufficient allocation of different capital assets in the right proportions. Supportive laws, policies, and regulations, responsible governance and secure tenure, and mutual trust will drive inclusive approaches to restoration decision-making and land use planning. This gives people agency to improve their health, livelihoods, and socio-economic prospects by regenerating ecosystem processes, functions, and services.

While land restoration can be initiated by individuals and communities, typically it is driven by governments, donors, NGOs, or other external stakeholders. They provide funding, resources, and expertise, partnering with local knowledge, skills, and capacities to implement and scale up regenerative land and water management practices. Government agencies support restoration efforts through assessments and planning, and by creating policies, regulatory, institutional, and budgetary frameworks that incentivize nature-based solutions. They also encourage harmonization, alignment, and coordination among donors to ensure engagement, efficiency, and effectiveness. Scientific institutions and civil society organizations also play an important role by providing data and tools, advocacy and communications support, or restoration volunteers.

Putting People Front and Center

Most of the examples in Part Two of this Outlook underscore the value of education, training, and capacity building, not just for local communities, but also for government officials, land managers, and development planners. New learning builds human and social capital, especially when focused on urgent local priorities. Practical experience from different disciplines and clear criteria are also needed to select the most appropriate restoration interventions.

At the same time, meaningful and sustained land restoration efforts should acknowledge the rights of indigenous peoples and local communities, promote gender equality and youth engagement, and help all stakeholders navigate financial, legal, and institutional issues.[88] Many successful restoration initiatives are implemented by local communities, often empowered by the protection of their rights and heritage. The examples show that inclusive and responsible governance of land resources is an effective way to balance trade-offs and harness synergies that optimize restoration outcomes.

Success also requires predictable finance, a sensitive balance between indigenous and scientific knowledge, and partnerships that can sustain human and technical capacities. Linking local engagement to national policies (e.g., poverty alleviation, food security, disaster risk reduction, rural development) can help ensure a responsive and well-aligned land restoration agenda that delivers tangible outcomes for people, nature, and the climate.

Vulnerable groups, such as small-scale farmers, women and youth, and indigenous and displaced peoples, often lack the human and social capital to engage in land restoration. This may be due to difficulties in accessing information and educational opportunities (human capital) to take advantage of restoration opportunities, or disempowerment and disenfranchisement arising from power imbalances or insecure tenure and resource rights (social capital). Gender, race, caste, class, age, or economic circumstances can also affect how people interact with their environment, and how different groups assess the value of different restoration outcomes.[89]

Inclusive and responsible land governance processes, along with trusted institutions, engender a sense of ownership, trust, and unity around a shared vision. By fulfilling the obligations of states and responsibilities of the private sector, communities and other stakeholders can be empowered to restore together. Collaboration mechanisms build social capital – the trust among a network of actors to manage trade-offs in a non-threatening, participatory, and transparent decision-making process. Investing in social capital means creating spaces or platforms for dialogue – local, regional, or national – that can avert or resolve legal issues and institutional conflicts, increase access to finance and extension services, and ensure equitable benefit sharing.[90] Integrated land use planning further strengthens social capital through administrative frameworks that legitimate land and resource rights and accommodate diverse social and economic preferences.

Women and Youth

Limited land rights, coupled with traditions, customs, or religious norms, often prevent women and girls from participating in and benefiting from restoration activities. These factors can restrict their ability to obtain reasonable and unbiased access to dispute resolution mechanisms or customary governance institutions.[91] Inclusive restoration begins with assessing and reforming legal, regulatory, customary, and administrative frameworks to be gender responsive. This approach honors their legitimate right to access and control land resources and, equally important, recognizes women and girls' critical role as primary caregivers and their important contribution to household health and income, food and water security, and sustainable development.

Gender-responsive land restoration is an obvious pathway to reduce poverty, hunger, and malnutrition.[92] In developing countries, women typically have major roles in both rural and urban agriculture – from seed collection, harvesting, and processing to sales in local markets. These roles typically come with other responsibilities, such as education, childrearing, or obtaining water. The recognition of women's land and resource rights will accelerate land restoration efforts by opening doors to markets and finance, training and extension services, and gender-appropriate technologies. Gender-responsive restoration projects and programmes embrace specific objectives, action plans, and budgets that foster women's participation and promote gender equality.[93] [94]

Land restoration will create millions of green jobs and other economic opportunities for a growing and youthful population. Creating attractive and meaningful employment opportunities can reduce the social unrest and political instability that accompany high rates of youth unemployment. The energy, talent, creativity, and pioneering spirit of young people can lead society to a more equitable and resilient future. With experience and knowledge of information and communication technologies, youth have become increasingly significant, vocal, and influential actors in local and global movements demanding climate action, food justice, and environmental stewardship while advocating for corporate responsibility and more sustainable consumption.[95]

Youth can and must play a significant role in the just transition to a regenerative restoration economy. Investing in young human capital by providing incentives and training for land restoration is key to transforming food systems, including supporting young farmers with more equitable rights of inheritance and long-term security of tenure. Most encouraging are the many young green entrepreneurs already engaged in regenerative pursuits. They are using practical tools and innovative technologies to boost agricultural yields, revitalize degraded land, and create long-term economic opportunities that are important for many poor rural communities struggling to recover from the COVID-19 pandemic. A new generation of young people and 'ecopreneurs' – Generation Restoration – is already working to build a more equitable and sustainable future based on restoring the planet.[96]

Information and Communications Technologies

The smartphone and 'direct to mobile' internet revolution show how information, apps, and communication technologies are already fundamental to everyday life for youth across the world. Alongside the 'e-agriculture' revolution, this instant connectivity offers an innovative pathway for integrating entrepreneurship and hi-tech solutions with regenerative and traditional practices in youth-led farming and related value-added enterprises.[97]

Indigenous Peoples and Local Communities

Indigenous peoples and local communities represent a vast store of human and social capital that must be respected and embraced to protect and restore natural capital. As proven land stewards, indigenous peoples and local communities will be vital to the success of the global land restoration agenda, but only if their rights are recognized and they are involved in the management of protected areas.[98] Indigenous and local knowledge, traditional governance, customary use, and management practices must be given equal footing alongside modern scientific methods. Addressing past injustices, respecting human rights, and restoring traditional governance are key priorities for the 'land back' movements gaining momentum around the world.[99] Businesses and land developers can do their part by engaging in partnerships with indigenous peoples and local communities to help obtain legal recognition of their customary lands as mandated by free, prior, and informed consent.[100]

Community-based restoration initiatives tend to be the most successful and occur across a range of land use types: crop and grazing lands, mixed use domains including urban agriculture, forests and woodlands, wetlands, or abandoned and waste lands.[101] Examples include drylands where farmer-managed natural regeneration has increased agricultural productivity, tree cover, and species diversity; tropical forest ecosystems where agroforestry methods produce high-value crops; and grasslands and savannas where silvopasture techniques benefit ecosystem health and pastoral livelihoods. Traditional and local knowledge employs long-established cultural values and practices to bolster adaptation strategies around food and water security, community wellbeing, and livelihood strategies. Refugees and displaced peoples can also make a valuable contribution to land restoration and development efforts while rebuilding their own autonomy and establishing new communities.

3.3.3 Framework for Restoring Natural Capital

As revealed in this Outlook's scenario analysis, business as usual is not an option. Countries can no longer afford slow incremental reforms within traditional economic development and national planning frameworks. Food and energy systems must continue to provide sustenance and fuel for the world's population, yet urgently need to be redesigned and redeployed to ensure positive outcomes for people and the planet. Repurposing subsidies and providing the right incentives can trigger the shift from resource-depleting models of production to those – such as conservation or regenerative agriculture, agroforestry, and other integrated production systems – that link resource efficiency gains to healthy and resilient food and energy systems.

Land restoration is receiving increased attention from communities, businesses, and governments alike. Examples from around the world clearly demonstrate that land and ecosystem restoration is a proven and cost-effective multiple benefits strategy for tackling interlinked challenges. Restorative actions can, in principle, be implemented in all settings and at many spatial scales, signifying that every country can custom design and implement its own unique land restoration agenda. A suite of regenerative land-based pathways can be tailored to local and national circumstances to deliver food production, water regulation, climate action, biodiversity and ecosystem services, green infrastructure, job creation, and inclusive governance.

Restoration pathways can be pursued in combinations that offer the potential for immediate actions and tangible benefits. A shift towards place-based, people-centered strategies and approaches will help improve the traction and success of restoration activities, and contribute to greater equity and inclusion, reduced poverty, improved food and water security, and many other targets contained in the Sustainable Development Goals. The pathways presented here are not prescriptive, rather they are indicative of what is relevant and practical, and which can be bundled to meet country and community needs to accelerate a just transition to a regenerative restoration economy.

Moving to a Crisis Footing: Making the Land the Focus

Protecting and restoring nature is an urgent priority, requiring a crisis footing. When political will, collective action, and sustained investment come together, global threats to humanity can be avoided or at least minimized. Investments in land and ecosystem restoration will increase when changes in societal attitudes are reflected in more responsible corporate and consumer behavior, strengthened policy, regulation and supply chains, short-term stimulus for recovery, and long-term planning for resilience. This mind shift will help galvanize the land restoration agenda and drive stakeholders to build on, and go beyond, existing frameworks to pursue their unique restorative pathways to recovery and resilience.

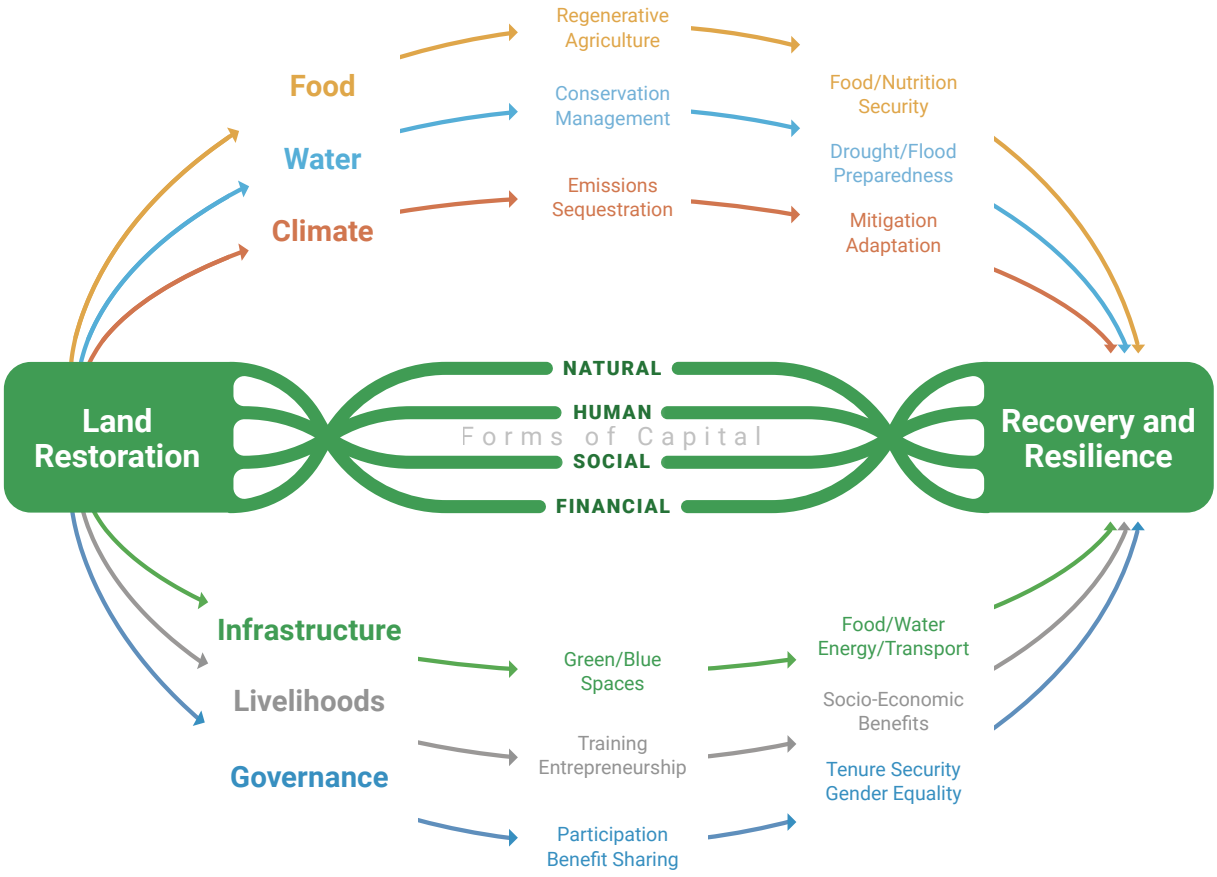
Governments are often responsible for creating the key enabling conditions that sustain the implementation of restoration projects and programmes. This includes ensuring a supportive policy, regulatory, legal, financial, and institutional environment that makes sufficient capacity and resources available to diverse stakeholders. Roadmaps with rapid targeted actions and incentive structures can be developed for a just transition in sectoral activities that are not sustainable or harmful to humans and the environment. This largely involves private sector collaboration and community engagement governed by strengthened regulatory and supply chain oversight.

No country can stand alone. International and regional cooperation among countries as well as other forms of collaborations, such as partnerships and coalitions, are essential to build, scale, and deliver the required levels of financial, human, and social capital to activate the land restoration agenda. At the same time, local and national authorities must be agile and flexible when faced with urgent land degradation challenges, and respond with rapid changes in policy, law, and regulations, coordinated implementation, re-allocation of budgets, devolution of power, or repurposing of administrative functions.

Bold decisions and investments made today will determine the quality of Life on Land tomorrow. This Outlook serves as a timely reminder of the steps needed to shape a prosperous and more secure future based on rights, rewards, and responsibilities.

Merging national action plans under the Rio Conventions presents an immediate opportunity to align restoration goals, targets, and commitments to simultaneously realize multiple benefits and maximize returns on investment. As a first step, countries could engage in ministerial consultations to harmonize, align, and coordinate individual national action plans (e.g., NDC, LDN, NBSAP) and map overlapping or complementary land restoration challenges and opportunities. Such a rationalization of mutually supportive measures would foster a coherent environment in which multi-sector coordination and private sector and civil society engagement could work together more productively to address multiple sustainability objectives and stay within planetary boundaries.

FIGURE 3.10 Land restoration pathways to recovery and resilience



Activating the Land Restoration Agenda

Nature-positive food production can happen almost everywhere, but is generally associated with rural and agricultural landscapes to:

- improve soil and water quality, land productivity and ecosystem resilience
- reduce hunger and food waste, and improve nutrition and human health
- cut greenhouse gas emissions (e.g., methane, nitrous oxide) and sequester carbon
- eliminate the use of harmful agrochemicals and inefficient water use

Water, essential for all life on Earth, can be effectively conserved and managed along with soil and biodiversity to:

- improve water flows, retention, quality, and availability
- increase drought preparedness and resilience
- enhance flood mitigation and disaster risk reduction
- adapt to changes in rainfall and weather patterns that increase water scarcity

Climate action, reducing human-induced global warming, is an urgent global priority for which all sectors of society can take immediate actions to:

- reduce greenhouse gas emissions and achieve net zero emissions by 2050
- increase carbon storage in soils and vegetation
- scale up climate-smart and regenerative farming practices
- enhance community resilience and reduce vulnerability and risk

Biodiversity conservation, preserving the wealth and variety of all species, is critical for human and planetary health and sustainability to:

- ensure the provision of ecosystem goods and services
- safeguard human, plant, and animal health
- protect the global public commons and establish well-connected conservation and protected area networks
- reduce disaster risk, regulate pests/diseases, and minimize the risk of future pandemics

Green (blue) infrastructure, usually associated with urban and peri-urban areas, can leverage the power of nature to protect rural and natural areas to:

- provide cost-effective services, such as water, energy, transport, and risk management, through integrated land use planning
- create more sustainable and efficient supply chains
- enhance physical and mental health, biodiversity values, and ecological connectivity
- increase water security and reduce waste and pollution

Job creation, aimed at preserving or restoring environmental quality, is a priority for all governments and societies, communities and individuals to:

- secure incomes and livelihoods, reduce poverty and hunger, and improve social welfare
- build the human, social, and financial capital needed to restore natural capital
- increase rural stability, reduce resource conflict, and manage urban growth
- create new skill sets and encourage entrepreneurship for a circular economy
- reduce forced migration and unplanned urban sprawl

Inclusive and responsible land governance, specifically a strengthening of tenure security and more robust integrated land use planning, is an administrative priority to:

- empower individuals and communities to take collective restorative action
- enable sectoral coordination and establish a wide range of public-private partnerships
- apply human rights-based approaches to safeguard a healthy and productive environment
- enhance transparency and accountability to foster trusted institutions in the public and private sectors

ENDNOTES

1 Strassburg, B.B., Iribarrem, A., Beyer, H.L., Cordeiro, C.L., Crouzeilles, R., Jakovac, C.C., Junqueira, A.B., Lacerda, E., Latawiec, A.E., Balmford, A. and Brooks, T.M., 2020. Global priority areas for ecosystem restoration. Nature, 586(7831), pp.724-729. https://doi.org/10.1038/s41586-020-2784-9

2 Stawarz S., (n.d.) Conservation in the UN Decade on Ecosystem Restoration. The Conservation Foundation (21 June). https://www.theconservationfoundation.org/conservation-in-the-un-decade-on-ecosystem-restoration/

3 United Nations, 2021. The United Nations Decade on Ecosystem Restoration Strategy. UN Decade on Ecosystem Restoration, UNEP, Nairobi and FAO, Rome. https://www.decadeonrestoration.org/strategy

4 UNCCD, 2019. Decision 26/COP.14 on Land tenure. Decision adopted at the 14th meeting of the Conference of the Parties on 13 September 2019. https://www.unccd.int/sites/default/files/sessions/documents/2019-11/26-cop14.pdf

5 UN Human Rights Council, 2021. Human rights and the environment. A/HRC/46/7. Resolution adopted by the Human Rights Council on 23 March 2021. https://undocs.org/A/HRC/RES/46/7

6 United Nations DESA, 2015. The 17 Goals. UN DESA. https://sdgs.un.org/goals

7 UNFCCC, 2015. The Paris Agreement. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

8 Mohammed, A.J. and Ghebreyesus, T.A., 2018. Healthy living, well-being and the sustainable development goals. Bulletin of the World Health Organization, 96(9), p.590. doi: 10.2471/BLT.18.222042. https://doi.org/10.2471/BLT.18.222042

9 Blissman, B., 2021. The United Nations' Sustainable Development Goals (SDGs): A Strategic Plan for Humanity. In World Scientific Encyclopedia of Climate Change: Case Studies of Climate Risk, Action, and Opportunity Volume 2 (pp. 43-61). https://doi.org/10.1142/9789811213953_0005

10 IRP, 2019. Land Restoration for Achieving the Sustainable Development Goals: An International Resource Panel Think Piece. Herrick, J.E., et al. UNEP, Nairobi. https://www.resourcepanel.org/reports/land-restoration-achieving-sustainable-development-goals

11 UN General Assembly, 2020. Implementation of the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa. A/RES/75/218. https://digitallibrary.un.org/record/3896583?ln=en

12 UNEP, 2021. Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate. UNEP, Nairobi. https://www.unep.org/resources/ecosystem-restoration-people-nature-climate

13 UNFCCC, 2021. Glasgow Leaders Declaration on Forests and Land Use. UN Climate Change Conference 2021. https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use

14 UN, 1992. United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992. https://www.un.org/en/conferences/environment/rio1992

15 Strassburg, B.B., Iribarrem, A., Beyer, H.L., Cordeiro, C.L., Crouzeilles, R., Jakovac, C.C., Junqueira, A.B., Lacerda, E., Latawiec, A.E., Balmford, A. and Brooks, T.M., 2020. Global priority areas for ecosystem restoration. Nature, 586(7831), pp.724-729. https://doi.org/10.1038/s41586-020-2784-9

16 UNCCD, (n.d.) Land Degradation Neutrality. UNCCD, Bonn. https://www.unccd.int/actions/achieving-land-degradation-neutrality

17 UNCCD, (n.d.) LDN Target Setting. UNCCD, Bonn. https://www.unccd.int/actions/ldn-target-setting-programme

18 Secretariat of the Convention on Biological Diversity, 2020. Global Biodiversity Outlook 5. CBD, Montreal. https://www.cbd.int/gbo5

19 The Bonn Challenge, 2020. The Bonn Challenge Homepage. IUCN, Gland. https://www.bonnchallenge.org

20 1t.org, (n.d.) A platform for the trillion tree community. World Economic Forum. https://www.1t.org

21 1t.org, (n.d.) Sahel and Great Green Wall. World Economic Forum. https://www.1t.org/sahel

22 G20 Research Group, 2020. G20 Environment Ministers Meeting, Riyadh, Saudi Arabia, November 22, 2020. Paragraph 16. http://www.g20.utoronto.ca/2020/2020-g20-environment-1122.html

23 Vetter, S., 2020. With Power Comes Responsibility–A Rangelands Perspective on Forest Landscape Restoration. Frontiers in Sustainable Food Systems, 4, p.225. https://doi.org/10.3389/fsufs.2020.549483

24 Convention on Wetlands, 2021. The Global Wetland Outlook: Special Edition 2021. Secretariat of the Convention on Wetlands, Gland. https://www.global-wetland-outlook.ramsar.org/outlook

25 Temperton, V.M., Buchmann, N., Buisson, E., Durigan, G., Kazmierczak, Ł., Perring, M.P., de Sá Dechoum, M., Veldman, J.W. and Overbeck, G.E., 2019. Step back from the forest and step up to the Bonn Challenge: how a broad ecological perspective can promote successful landscape restoration. Restoration Ecology, 27(4), pp.705-719. https://doi.org/10.1111/rec.12989

26 Lewis, S.L., Wheeler, C.E., Mitchard, E.T. and Koch, A., 2019. Regenerate natural forests to store carbon. Nature, 568(7750), pp.25-28. https://media.nature.com/original/magazine-assets/d41586-019-01026-8/d41586-019-01026-8.pdf

27 Veldman, J.W., Overbeck, G.E., Negreiros, D., Mahy, G., Le Stradic, S., Fernandes, G.W., Durigan, G., Buisson, E., Putz, F.E. and Bond, W.J., 2015. Where tree planting and forest expansion are bad for biodiversity and ecosystem services. BioScience, 65(10), pp.1011-1018. https://doi.org/10.1093/biosci/biv118

28 Lewis, S.L., Wheeler, C.E., Mitchard, E.T. and Koch, A., 2019. Regenerate natural forests to store carbon. Nature, 568(7750), pp.25-28. https://media.nature.com/original/magazine-assets/d41586-019-01026-8/d41586-019-01026-8.pdf

29 van der Esch S., Sewell A., Bakkenes M., Berkhout E., Doelman J., Stehfest E., Langhans C., Fleskens L., Bouwman A., and ten Brink B., 2021. The global potential for land restoration: Scenarios for the Global Land Outlook 2. The Hague, PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/the-global-potential-for-land-restoration-scenarios-for-the-global-land-outlook-2

30 van Vliet, M. and Kok, K., 2015. Combining backcasting and exploratory scenarios to develop robust water strategies in face of uncertain futures. Mitigation and adaptation strategies for global change, 20(1), pp.43-74. https://doi.org/10.1007/s11027-013-9479-6

31 Berkhout E., Kodsi E., van den Berg M., van Zeist W., Mwandendu R., van der Esch S., Rembold F, Meroni M., and Cherlet M, 2021. Future Perspectives on Land for Eastern Africa Pilot study focusing on Ethiopia and Kenya. UNDP, Nairobi. https://www.pbl.nl/en/publications/future-perspectives-on-land-for-eastern-africa

32 D.Aguiar A., Collste D., Harmáčková Z., Pereira L., Selomane O., Galafassi D., and Van der Leeuw S., 2020. Co-designing global target-seeking scenarios: A cross-scale participatory process for capturing multiple perspectives on pathways to sustainability. Global Environmental Change, Vol 65, 103298. https://doi.org/10.1016/j.gloenvcha.2020.102198

33 Sewell A. van der Esch S., and Löwenhardt H., 2020. Goals and Commitments for the Restoration Decade. A global overview of countries' restoration commitments under the Rio Conventions and other pledges. The Hague, PBL Netherlands Environmental Assessment Agency https://www.pbl.nl/en/publications/goals-and-commitments-for-the-restoration-decade

34 Sewell A. van der Esch S., and Löwenhardt H., 2020. Goals and Commitments for the Restoration Decade. A global overview of countries' restoration commitments under the Rio Conventions and other pledges. The Hague, PBL Netherlands Environmental Assessment Agency https://www.pbl.nl/en/publications/goals-and-commitments-for-the-restoration-decade

35 van der Esch S., Sewell A., Bakkenes M., Berkhout E., Doelman J., Stehfest E., Langhans C., Fleskens L., Bouwman A., and ten Brink B., 2021. The global potential for land restoration: Scenarios for the Global Land Outlook 2. The Hague, PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/the-global-potential-for-land-restoration-scenarios-for-the-global-land-outlook-2

36 Atwoli, L., Baqui, A.H., Benfield, T., Bosurgi, R., Godlee, F., Hancocks, S., Horton, R., Laybourn-Langton, L., Monteiro, C.A., Norman, I. and Patrick, K., 2021. Call for emergency action to limit global temperature increases, restore biodiversity, and protect health. Journal of Health, Population and Nutrition, 40(1), pp.1-4. https://doi.org/10.1093/nutrit/nuab067

37 Sewell, A., Bouma, J. and van der Esch, S., 2016. Investigating the challenges and opportunities for scaling up ecosystem restoration. The Hague, PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/investigating-the-challenges-and-opportunities-for-scaling-up-ecosystem-restoration

38 van der Esch S., Sewell A., Bakkenes M., Berkhout E., Doelman J., Stehfest E., Langhans C., Fleskens L., Bouwman A., and ten Brink B., 2021. The global potential for land restoration: Scenarios for the Global Land Outlook 2. The Hague, PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/the-global-potential-for-land-restoration-scenarios-for-the-global-land-outlook-2

39 Smucker, T.A. and Nijbroek, R., 2020. Foundations for convergence: Sub-national collaboration at the nexus of disaster risk reduction, climate change adaptation, and land restoration under multi-level governance in Kenya. International Journal of Disaster Risk Reduction, 51, p.101834. https://doi.org/10.1016/j.ijdrr.2020.101834

40 GEF, 2021. Land degradation. GEF, Washington DC. https://www.thegef.org/topics/land-degradation

41 GEF, 2021. Impact programs. GEF, Washington, DC. https://www.thegef.org/topics/impact-programs

42 GEF, 2022. 8th Replenishment Programming Directions. GEF, Washington DC. https://www.thegef.org/sites/default/files/documents/2022-01/GEF_R.08_17_GEF-8_Programming_Directions.pdf

43 The World Bank, 2021. Forests and Terrestrial Ecosystems (Landscapes). The World Bank, Washington, DC. https://www.worldbank.org/en/topic/forests#2

44 UNFCCC, 2021. Glasgow Leaders Declaration on Forests and Land Use. UN Climate Change Conference 2021. https://ukcop26.org/glasgow-leaders-declaration-on-forests-and-land-use

45 UNFCCC, 2021. The Global Forest Finance Pledge. UN Climate Change Conference 2021. https://ukcop26.org/the-global-forest-finance-pledge

46 UNFCCC, 2021. COP26 IPLC Forest Tenure Joint Donor Statement. UN Climate Change Conference 2021. https://ukcop26.org/cop26-iplc-forest-tenure-joint-donor-statement

47 UNFCCC, 2021. COP26 Congo Basin Joint Donor Statement. UN Climate Change Conference 2021. https://ukcop26.org/cop26-congo-basin-joint-donor-statement

48 UNCCD, 2021. Great Green Wall Event at COP26. UN Climate Change Conference 2021. https://www.unccd.int/news-events/great-green-wall-event-cop26

49 UNFCCC Race to Zero, 2021. Leading financial institutions commit to actively tackle deforestation. UNFCCC Race to Zero. https://racetozero.unfccc.int/leading-financial-institutions-commit-to-actively-tackle-deforestation

50 Löfqvist, S. and Ghazoul, J., 2019. Private funding is essential to leverage forest and landscape restoration at global scales. Nature ecology & evolution, 3(12), pp.1612-1615. https://doi.org/10.1038/s41559-019-1031-y

51 UNCCD, (n.d.) Land Degradation Neutrality Fund. UNCCD, Bonn. https://www.unccd.int/actions/impact-investment-fund-land-degradation-neutrality

52 IDH The Sustainable Trade Initiative and Mirova, 2021. Inclusive Investments in Sustainable Land Management to Help Achieve Land Degradation Neutrality. Learning Brief. IDH. https://www.idhsustainabletrade.com/ldn-insights-report

53 URAPI Sustainable Land Use, 2020. The Café Selva Norte Project Peru. URAPI Sustainable Land Use. https://www.urapi.co/copy-of-café-selva-norte

54 IDH The Sustainable Trade Initiative, 2019. Land Degradation Neutrality (LDN) Fund makes first investment towards sustainable land management. IDH. https://www.idhsustainabletrade.com/news/land-degradation-neutrality-ldn-fund-makes-first-investment-towards-sustainable-land-management

55 Mirova, 2021. Land Degradation Neutrality Fund Impact Report 2021. Mirova. https://www.mirova.com/en/ideas/ldn-land-degradation-neutrality-fund-impact-report-2020

56 UNEP, 2020. New Restoration Seed Capital Facility launched to promote investment in forest landscape restoration. UNEP, Nairobi. https://www.unep.org/news-and-stories/press-release/new-restoration-seed-capital-facility-launched-promote-investment

57 WRI, 2022. The Land Accelerator. WRI, Washington, DC. https://www.wri.org/initiatives/land-accelerator

58 The Global Innovation Lab for Climate Finance, (n.d.) TerraFund: Rural Prosperity Bond. The Global Innovation Lab for Climate Finance https://www.climatefinancelab.org/project/rural-prosperity-bond

59 Apple, 2021. Apple and partners launch first-ever $200 million Restore Fund to accelerate natural solutions to climate change. Press Release. Apple (15 April). https://www.apple.com/newsroom/2021/04/apple-and-partners-launch-first-ever-200-million-restore-fund

60 Kirakosian M., and Barbin Perron V., 2021. BNP Paribas AM launches ecosystem restoration fund. Citywire (07 June). https://citywireselector.com/news/bnp-paribas-am-launches-ecosystem-restoration-fund/a1515869

61 The World Bank, 2022. The Food Systems, Land Use and Restoration (FOLUR) Impact Program. Brief. The World Bank, Washington, DC. https://www.worldbank.org/en/topic/agriculture/brief/the-food-systems-land-use-and-restoration-folur-impact-program

62 UNDP, 2020. Moving Mountains: Unlocking Private Capital for Biodiversity and Ecosystems. UNDP, New York. https://www.biofin.org/knowledge-product/moving-mountains-unlocking-private-capital-biodiversity-and-ecosystems

63 Aronson, J., Milton, S. and Blignaut, J., 2006. Conceiving the science, business, and practice of restoring natural capital. Ecological Restoration, 24(1), pp.22-24. https://www.jstor.org/stable/43442991

64 Boffo, R., Marshall, C. and Patalano, R., 2020. ESG Investing: Environmental Pillar Scoring and Reporting. OECD, Paris. https://www.oecd.org/finance/ESG-Investing-Environmental-Pillar-Scoring-and-Reporting.pdf

65 Koller T. Nuttall R., Henisz W., 2019. Five ways that ESG creates value McKinsey & Company (14 November). https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/five-ways-that-esg-creates-value

66 World Economic Forum, 2020. Measuring Stakeholder Capitalism Towards Common Metrics and Consistent Reporting of Sustainable Value Creation. White Paper. World Economic Forum, Geneva. http://www3.weforum.org/docs/WEF_IBC_Measuring_Stakeholder_Capitalism_Report_2020.pdf

67 BNP Paribas, 2021. BNP Paribas Ecosystem Restoration. BNP Paribas, Luxembourg. https://www.bnpparibas-am.lu/intermediary-fund-selector/our-funds/featured-funds/bnp-paribas-ecosystem-restoration

68 Amaro S., 2021. Blackrock's former sustainable investing chief now thinks ESG is a 'dangerous placebo'. CNBC (24 August). https://www.cnbc.com/2021/08/24/blackrocks-former-sustainable-investing-chief-says-esg-is-a-dangerous-placebo.html

69 Global Sustainable Investment Alliance, 2021. Global Sustainable Investment Review 2020. Global Sustainable Investment Alliance. http://www.gsi-alliance.org/wp-content/uploads/2021/08/GSIR-20201.pdf

70 Arakwiye, B., Mahamoudou, S., and Chomba, S., 2021. How much land is being restored in Africa? We Don't Yet Know. World Resources Institute (14 October). https://www.wri.org/insights/how-challenges-solutions-land-restoration-monitoring-africa

71 Gann, G.D., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson, J., Hallett, J.G., Eisenberg, C., Guariguata, M.R., Liu, J., Hua, F., Echeverria, C., Gonzales, E.K., Shaw, N, Decleer, K., and Dixon, K.W., 2019. International principles and standards for the practice of ecological restoration. Second edition. Restoration Ecology S1-S46. https://doi.org/10.1111/rec.13035

72 OECD, 2021. Agricultural Policy Monitoring and Evaluation 2021: Addressing the Challenges Facing Food Systems, OECD Publishing, Paris. https://www.oecd.org/publications/agricultural-policy-monitoring-and-evaluation-22217371.htm

73 Gisselquist, R.M. and Tarp, F., 2019. Aid effectiveness – growth and beyond. UN WIDER Policy Brief accompanying the Journal Special Issue 'Aid impact and effectiveness:' Politics and governance, 7(2), Cogitato Press. https://www.wider.unu.edu/publication/aid-effectiveness-3

74 World Economic Forum, 2020. Measuring stakeholder capitalism: Towards common metrics and consistent reporting of sustainable value creation, White Paper prepared in collaboration with Deloitte, EY, KPMG and PwC. World Economic Forum, Geneva. https://www.weforum.org/reports/measuring-stakeholder-capitalism-towards-common-metrics-and-consistent-reporting-of-sustainable-value-creation

75 Kimbrough L., 2021. Global restoration now has an online meeting point. Mongabay (23 July). https://news.mongabay.com/2021/07/global-restoration-now-has-an-online-meeting-point

76 Gann, G.D., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson, J., Hallett, J.G., Eisenberg, C., Guariguata, M.R., Liu, J., Hua, F., Echeverria, C., Gonzales, E.K., Shaw, N,. Decleer, K., and Dixon, K.W., 2019. International principles and standards for the practice of ecological restoration. Second edition. Restoration Ecology S1-S46. https://doi.org/10.1111/rec.13035

77 Yin, X., Li, J., Kadry, S.N. and Sanz-Prieto, I., 2021. Artificial intelligence assisted intelligent planning framework for environmental restoration of terrestrial ecosystems. Environmental Impact Assessment Review, 86, p.106493. https://doi.org/10.1016/j.eiar.2020.106493

78 GEO, (n.d.) Land Degradation Neutrality Initiative. Group on Earth Observation, Geneva. https://earthobservations.org/geo_ldn.php

79 World Economic Forum, (n.d.) Homepage, A platform for the trillion tree community. https://www.1t.org

80 WRI, (n.d.) TerraMatch Initiatives. WRI, Washington, DC. https://www.wri.org/initiatives/terramatch

81 Restor, 2021. Homepage Your home for Nature Restoration. Restor, Zurich. https://restor.eco

82 IUCN, (n.d.) Barometer of Restoration. IUCN, Gland. https://www.iucn.org/theme/forests/projects/barometer-restoration

83 FAO and UNEP, 2021. Briefing note on the Task Force on Monitoring for the UN Decade on Ecosystem Restoration 2021-2030. UN Decade on ecosystem Restoration (12 May). https://www.decadeonrestoration.org/task-forces/monitoring

84 Climate Focus, (n.d.) Homepage. https://www.climatefocus.com

85 Serrat, O., 2017. The sustainable livelihoods approach. Knowledge solutions (pp. 21-26). Springer, Singapore. https://link.springer.com/chapter/10.1007/978-981-10-0983-9_5

86 Ostrom, E. and Ahn, T.K., 2007. The meaning of social capital and its link to collective action. In Svendsen G.T., Svendsen G.L. Handbook of social capital: The troika of sociology, political science and economics, Northampton: Edward Elgar pp.17-35. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.472.3769&rep=rep1&type=pdf

87 Jalil, A., Yesi, Y., Sugiyanto, S., Puspitaloka, D. and Purnomo, H., 2021. The Role of Social Capital of Riau Women Farmer Groups in Building Collective Action for Tropical Peatland Restoration. Forest and Society, pp.341-351. https://doi.org/10.24259/fs.v5i2.12089

88 Stanturf J. A., et al., 2020. Forest Landscape Restoration Implementation: Lessons learned from selected landscapes in Africa, Asia and Latin America. Occasional Paper No. 33. IUFRO. Vienna. 63 p. https://www.iufro.org/index.php?id=7026

89 Science Task Force for the UN Decade on Ecosystem Restoration, 2021. Science-based ecosystem restoration for the 2020s and beyond. Gland, Switzerland: IUCN. 60pp. https://www.decadeonrestoration.org/publications/science-based-ecosystem-restoration-2020s-and-beyond

90 Sales, E., Rodas, O., Valenzuela, O., Hillbrand, A. and Sabogal, C., 2016. On the way to restore Guatemala's degraded lands: Creating governance conditions. World Development Perspectives, 4, pp.16-18. https://doi.org/10.1016/j.wdp.2016.11.010

91 Namubiru-Mwaura, E., 2014. Land tenure and gender: Approaches and challenges for strengthening rural women's land rights. Gender, Equality and Development, Women's Voice, Agency, and Participation Research Series 6. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/21033

92 Meinzen-Dick, R., Suseela, S., Quisumbing, A.R., Doss, C.R., and Theis, S., 2017. Women's land rights as a pathway to poverty reduction: A framework and review of available evidence. IFPRI Discussion Paper 1663. Washington, DC. International Food Policy Research Institute. https://doi.org/10.1016/j.agsy.2017.10.009

93 IUCN, 2017. Gender-responsive restoration guidelines: A closer look at gender in the Restoration Opportunities Assessment Methodology. IUCN, Gland. https://portals.iucn.org/library/node/46693

94 UN Women, Global Mechanism of the UNCCD, and IUCN, 2019. A manual for gender-responsive land degradation neutrality transformative projects and programmes. Global Mechanism of the UNCCD and UN Women, pp.1-60. https://www.unwomen.org/en/digital-library/publications/2019/09/manual-for-gender-responsive-land-degradation-neutrality-transformative-projects-and-programmes

95 Thew, H., 2018. Youth participation and agency in the United Nations Framework Convention on Climate Change. International Environment Agreements. 18:369–89. https://doi.org/10.1007/s10784-018-9392-2

96 UNEP, 2021.Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate. UNEP, Nairobi. https://www.unep.org/resources/ecosystem-restoration-people-nature-climate

97 Brand N., and Galdava E., 2019. Engaging youth in agriculture through information and communication technologies. Case studies, USAID. https://www.usaid.gov/sites/default/files/documents/15396/Feed-the-Future-CaseStudy-Youth-Ag-ICT.pdf

98 Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C.J., Watson, J.E., Zander, K.K., Austin, B., Brondizio, E.S. and Collier, N.F., 2018. A spatial overview of the global importance of Indigenous lands for conservation. Nature Sustainability, 1(7), pp.369-374. https://www.nature.com/articles/s41893-018-0100-6

99 Yellowhead Institute, 2019. Land Back. A Yellowhead Institute Red Paper. https://redpaper.yellowheadinstitute.org

100 ILO, 1989. C169-Indigenous and Tribal Peoples Convention, 1989 (169). https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:55:0::NO::P55_TYPE,P55_LANG,P55_DOCUMENT,P55_NODE:REV,en,C169,/Document

101 van Haren, N., Fleiner,R., Liniger, H., and Harari, N., 2019. Contribution of community-based initiatives to the sustainable development goal of Land Degradation Neutrality. Environmental Science and Policy, 94, 211-219. https://doi.org/10.1016/j.envsci.2018.12.017

ANNEX: **DONOR COUNTRY PROFILES**

REPUBLIC OF KOREA

Achieving LDN at Home and Abroad

The Republic of Korea is a leading champion of the global land restoration agenda, fully focused on achieving its national Land Degradation Neutrality (LDN) targets through multiple pathways, such as urban natural regeneration, transboundary and protected areas management, and international cooperation and finance. By financing restoration activities on the ground, the Korea Forest Service is also supporting peace and development initiatives in countries around the world so that they can meet their LDN and biodiversity goals.

Global Initiatives

The **Changwon Initiative** (under the UNCCD) was launched in 2011 to help consolidate the UNCCD's scientific foundations and support processes to develop and field test the concept of LDN. By supporting a decade's worth of projects on the ground – such as the Greening Drylands partnership and the Land for Life programme – the initiative has successfully showcased a broad range of land management solutions, including the promotion of the LDN target-setting process that currently engages over 130 countries.[1] It has served as an advocator, amplifier, and accelerator for achieving LDN locally and globally with the overall objective of addressing the global challenge of desertification and land degradation.

Wise management of shared natural resources in cross-border situations can create platforms for dialogue, confidence building, and cooperation to avoid new grievances and environmental degradation.[2]

The **Peace Forest Initiative** (under the UNCCD) aims to promote cooperation between countries to restore degraded land and forest in fragile and post-conflict locations while building peace and confidence. It is seen as an innovative way to link peace and security to voluntary LDN targets set by countries under the UNCCD.[3] The initiative will provide guidance on ensuring transparency of natural resource contracts, payments, and the social and environmental benefits of activities; improving tenure security and resource rights; engaging relevant stakeholders in decision-making; and maintaining positive transboundary dynamics that draw on national and local capacities for resolving disputes. The UNCCD secretariat collaborates with key partners, donors, technical experts, and international organizations to deliver on these objectives.

Natural regeneration is often a cost-effective, nature-based tool for achieving large-scale restoration objectives and climate mitigation targets that enhances resilience, supports local biodiversity, and supplies multiple ecosystem goods and services.[4]

The **Forest Ecosystem Restoration Initiative** (under the Convention on Biological Diversity) explicitly targets activities that enhance the role of natural regeneration as an integral component of forest and landscape restoration. In many tropical regions, natural regeneration is rarely recognized as a legitimate restoration or reforestation intervention and, as a result, is usually ineligible for support or economic incentives. The initiative supports developing countries, providing direct financial and technical support to pilot restoration projects that test a variety of innovative restoration techniques while compiling and disseminating lessons learned.[5]

The **Implementation of the Forest and Landscape Restoration Mechanism** (under the Food and Agriculture Organization) was established in 2014 to play a leading role in forest and landscape restoration at global, regional, and national levels. Its first phase, which ended in 2020, helped create a viable and sustainable mechanism for technical assistance and monitoring. The second phase, running until 2025 through the first half of the UN Decade on Ecosystem Restoration, will focus on large-scale restoration activities.[6]

Regional Cooperation

Cooperation on environmental issues in the northeast Asia region has advanced significantly over the last few decades. The unique and shared challenges of desertification, land degradation and drought, and sand and dust storms are an important catalyst of increased bilateral and multilateral collaboration to promote and implement sustainable land management and ecosystem restoration, in parallel with other nature-based solutions to common environmental concerns.[7]

The **Asia Forest Cooperation Organization** (AFoCO) was established in 2018 under the leadership of the Republic of Korea. Since its inception, AFoCO has implemented a range of regional- and country-specific projects to combat land and forest degradation and climate change, contributing to achieving LDN in Asia. AFoCO has also been working to build region-wide capacity in sustainable land and forest management and climate change mitigation and adaptation.

Between 2001 and 2005, the Republic of Korea and the People's Republic of China jointly funded and implemented afforestation projects in China to combat desertification and mitigate the impacts of sand and dust storms. The projects were conducted in five different sites: Baiyin City (Gansu), Pingluo County (Ningxia), Tongliao City (Inner Mongolia), Xiuwen County (Guizhou), and Turpan City (Xinjiang). The Republic of Korea sent forest restoration experts to the project sites and provided technical support. Since their completion, the National Institute of Forest Science of the Republic of Korea has been working with the Chinese Academy of Forestry to jointly monitor and evaluate the project sites, building databases to improve plantation technology and productivity. The benefits delivered by these projects included reduced soil erosion, mitigation of the impact of sand and dust storms, prevention of flood damage, increased forest cover, and wind erosion control and forest cover increase.[8] The projects also provided socio-economic benefits such as improved livelihoods and agricultural development linked to increased crop production, fruit plantations, and local ecotourism.

National Efforts

Facilitated Planning and Urban Regeneration

New forms of inclusive governance – when guided and facilitated by intermediaries such as state-funded or independent organizations – can help mobilize citizen participation in decision-making. In this context, land use planning and urban regeneration form the core of the Republic of Korea's urban policies. Under the 2013 Special

Act on the Promotion of and Support for Urban Regeneration, implementation plans for zoning imposed legally binding restrictions on land use and aimed to promote social inclusion, job creation, and economic revitalization.[9] Over the past decade, the Seoul Metropolitan Government has set up intermediary organizations for facilitated planning, leading to more effective management of degenerated urban areas. These inclusive governance arrangements have created partnerships between communities and local authorities, which have expanded participation in diverse areas of urban life, such as the daylighting of rivers and streams. One challenge has been establishing a common language between citizens and planners to leverage local knowledge and facilitate more inclusive urban regeneration.[10]

Restoration in the Baekdudaegan

For the past 50 years, the Republic of Korea has been subjected to massive landscape degradation, with mountain ranges scarred by limestone quarrying and road construction. The Baekdudaegan is not only a mountain range, but it is the spine of the entire Korean Peninsula that taps into the cultural resonances of its geography and ecological character.[11] The 1,600-kilometer-long mountain chain is a biodiversity hotspot that is protected in the south by a network of protected areas, including eight national and one provincial park, and two Ramsar sites.[12] Reforestation is a critical aspect of the ecological restoration needed to realize a vision in which a restored Baekdudaegan can support enhanced regional cooperation. Since the early 2000s, the Korea Forest Service has implemented various policies to sustainably manage natural resources, including ten-year plans with pilot restoration projects that engage academia and local communities, and combine long-term monitoring with research and educational activities for the public. Regenerative projects, involving military bases and private companies, focus on landscape restoration, reforestation and revegetation, ecological connectivity, and habitat protection.[13]

PEOPLE'S REPUBLIC OF CHINA

Building an Ecological Civilization

China has long stressed the need to build an ecological civilization,[14] both within the country and globally, to implement international commitments supporting sustainable development. This concept has been integrated into all aspects of social and economic development, including territorial and spatial planning, sustainable production and consumption patterns, large-scale programmes for ecosystem conservation and restoration, and the establishment of an enabling environment, including mechanisms for ecological compensation. Over the last 10 years, China has established an integrated spatial planning system that focuses on three functional zones: permanent farmland, ecological protection, and industrial and rural-urban development. These zones are delineated by three redlines with different development-intensity levels assigned to each. This ensures balanced land use for food security, ecosystem services, and socio-economic development.[15] The minimum amount of basic arable land under biological protection is set at 1.8 billion mu (1.3 billion hectares), which in accordance with the 14th Five-Year Plan will account for 25% of the total land area under spatial planning.[16]

Master Plan for Environmental Protection and Restoration

Within this system, large-scale ecological protection and restoration interventions will focus on 'improving the system of ecological safety barriers' and 'building national reserves'. To intensify restoration efforts, the government recently launched a Master Plan for Major National Ecological System Protection and Restoration Projects (2021-2035).[17] The plan will build on projects and programmes, some of which began in the 1970s, including the Three-North Forest Shelterbelt, and other projects in the Middle and Lower Reaches of the Yangtze, the Key Projects of Soil and Water Conservation, Sand and Dust Storm Source Control around Beijing and Tianjin, conversion of degraded crop and grazing lands to forest and grassland, Comprehensive Control of Rocky Desertification in Karst Areas, Natural Forest Resource Protection, and wildlife conservation and nature reserve development. New projects and programmes will take an integrated landscape approach to enhance ecological integrity and connectivity of mountains, waters, forests, farmlands, lakes,grasslands, and sand dunes.[18]

By the end of 2019, forest coverage has increased for 30 consecutive years and 11,800 nature reserves have been protected, accounting for 18% of the total land area.[19] In addition, wildlife habitat conditions have been improved and restored, and ecological connectivity has been significantly enhanced as has the quality and delivery of ecosystem services. Between 2000 and 2017, there was a net increase of 1.35 million square kilometers of green areas in China, equivalent to an increase of 17.8%. Forests and croplands contributed 42% and 32%, respectively, to the net increase in leaf area of China.[20] Through a combination of programmes, over 80 million hectares of grassland were enclosed (with grazing banned) and another 66 million hectares under rehabilitation and restoration programmes.[21] Over 50% of wetlands are under effective protection by 2020.

In 2021, China released a new guideline to deepen reforms to the ecological compensation mechanism to accelerate the building of an ecological civilization, and realize long-term goals set for 2025 and 2035. The guideline details the classified compensation system for rivers, natural forests, and wetlands and contains enhanced fiscal support with market-oriented and diversified compensation measures.[22]

As a leader in greening the world, China has made great strides in combating desertification and land degradation and mitigating the impacts of drought. Before the end of the last century, the area of desertification used to increase annually by 10,400 square kilometers, but now the area decreases by 2,424 square kilometers per year. The projects below illustrate how China implements land restoration to effectively address desertification and land degradation of different types through technical and business innovations at the local level.

Controlling Desertification and Land Degradation to Improve Local Livelihoods

Liangzhou District (Gansu) has a significant extent of arable land that is threatened by desertification. In response, the local government is tackling the threat by funding a mix of advanced technical measures, new policies, and institutional reforms, and targeted market-driven desertification control. Technical cooperation and exchanges with research institutes have been strengthened, and cooperative agreements have been signed with local businesses for afforestation and dryland management, increasing social welfare and job creation in the region. Independent contractors are allowed to engage in protection and restoration activities while keeping land rights unchanged and wildlife undisturbed. Project results include 165 kilometers of sand-fixing forest belts built along roads and canals. Major sand dunes have been stabilized and vegetation coverage has doubled, reclaiming a total of over 114 square kilometers of formerly desertified land.

To improve the effectiveness of land restoration, innovative techniques and approaches were applied. New technologies have been adopted, such as timing planting in good soil moisture, pre-treating seedling roots in mud, and grids for sand-fixation ahead of planting. Awareness raising among local communities and businesses is also common. The local business sector is often involved in contracting, employing, and sometimes renting land from local communities, according to relevant laws (such as law on Prevention and Control of Sandification) in China. Market-related ecosystem services worth millions of USD have arisen from the different projects through, for example, the sale of Chinese herbal medicine from saxaul (Haloxylon ammodendron) shrubs. Often, multi-stakeholder partnerships are involved in finance and implementation, including the public sector (national and city/district/local government), multilateral and bilateral organizations, national foundations, universities and research institutions, NGOs, youth groups, and the business sector.

Lingwu City (Ningxia) developed a project – Six-in-One Desertification Control System at the Baijitan Forest Farm – that employs multiple forms of defense to create a barrier to prevent the Mu Us Desert from advancing. On the frontline are two vegetative shelter belts comprised of drought-tolerant shrubs to prevent the encroachment of the desert. A second line of defense consists of forest shelter belts with sustainable harvesting opportunities. There are also two circular industries where afforestation is linked to crops, livestock, and poultry. In addition, an emerging ecotourism industry promotes eco-awareness. Thousands of hectares of desertified land were rehabilitated, forming a 62-kilometer-long barrier that is 20-30 kilometers wide. It prevents the Mu Us Desert from moving both southwards and westwards.

Before and after desertification control in the Mu Us Desert, China.

Yuyang District of Yulin (Shaanxi) followed the same approach used in Lingwu. Eight major forestry and grassland projects were launched with demonstration zones for the wider region. Grassland zones were established to prevent sandstorms, and regenerative forest management practices helped to establish a new industry base, including for ecotourism. Five bases have been established for orchards, health resorts, floral nurseries, forage-grass, and mulberry silk industries. A comprehensive, rule-based ecological conservation system has been established, encompassing protection at source, procedural oversight, individual accountability, and mechanisms for diversified investment and compensation. As a result, the landscape has been transformed with 50% forest coverage, urban greenery at 34%, and over 55% of eroded land successfully treated. Taken together, these measures have improved both the local economy and ecology.

In the **Axla Desert** (Inner Mongolia), Chinese entrepreneurs established the Society of Entrepreneurs and Ecology to combat regional desertification and address national environmental challenges. The region is one of the largest sources of sand and dust storms. The Axla project was designed to appeal to those outside the region, with nearly 500 million people participating, including farmers and herdsman promoting the project through online and offline communications. The objective is to plant 100 million saxaul shrubs between 2014-2023 to halt desertification, reduce land degradation in source areas of sandstorms, and raise the living standards of local herders. The goal is to maintain vegetative areas to prevent three deserts from converging: the first phase of the project involved setting up nine afforestation demonstration sites with village communities. In the second phase, afforestation will be done along provincial roads and the 'sand transport channels' of the three deserts that will be linked to the demonstration sites by corridors.

REPUBLIC OF TÜRKIYE

Working to Achieve LDN Step-by-Step

The Ankara Initiative

In the context of the Sustainable Development Goals (SDGs) and with a commitment to achieve Land Degradation Neutrality (LDN) by 2030, the Ankara Initiative was launched at the UNCCD COP12 in Ankara (2015) by the Government of the Republic of Türkiye to strengthen the implementation of the convention. The initiative aims to support the global sustainable development agenda and leverage the lessons learned from Türkiye's experience and approaches to land management. As a predominantly arid and semi-arid country, Türkiye has invested heavily in land rehabilitation and restoration. Based on its own experience, the country has been supporting other affected countries, particularly in Africa, to build capacity through training and skill development. The Ankara Initiative leverages the full range of these skills, expertise, and experience to provide practical support for the achievement of LDN.

Breath for the Future Campaign

On National Afforestation Day in 2019, Türkiye set a Guinness World Record by planting the most saplings (303,150) in one hour, breaking the previous record. Over 13 million saplings were planted across the country on that day.[23] In 2020, 83 million saplings were planted nationwide as part of the Breath for the Future Campaign. The initiative was organized by Türkiye's Ministry of Agriculture and Forestry with the support of the Ministry of Foreign Affairs and the Cooperation and Coordination Agency, with over 20 countries from Africa, Europe, and Asia participating in similar campaigns.[24]

Lessons Learned from LDN

The lessons learned from Türkiye's experience in several projects demonstrate that achieving LDN targets is a step-by-step process involving both biophysical and governance activities. To achieve global or regional restoration goals, the first step often starts at the national level with target setting, policy development, and identifying legal, regulatory, and institutional gaps as well as strengthening the multi-sectoral planning processes. This involves a number of government entities, such as agriculture, desertification and erosion, forestry, conservation and parks, and research institutes. Multiple stakeholders participate, including sub-national governments, civil society, local communities, educational institutions, the private sector, UN entities, donors, and funders. The allocation of funds is key considering that there are often multiple donors for each project.

Capacity development for stakeholders is a common element in many of these projects. Training and tools focus on the protection, use, and regeneration of resources in both production and natural areas through sustainable forest and agricultural land management, including nurseries and product marketing. For example, within the scope of the Sustainable Land Management and Climate-Friendly Agriculture Project, 24 farmer field schools were established. Poverty is also directly addressed through income generation and the distribution of goods to disadvantaged people to break the link between poverty and the degradation of natural resources in local communities. A common goal in all projects is to increase the health and productivity of land by funding the rehabilitation of forests and rangelands and the uptake of good practices in agricultural lands that contribute to biodiversity and ecosystem services. To fully assess the level of benefits generated, project results are monitored and evaluated, and the lessons learned are disseminated. The intention is that these projects will be replicated and scaled up to the national level, as demonstrated by the LDN approach in the Upper Sakarya Basin.

The projects showcased illustrate the diverse activities needed to combat desertification and land degradation. A participatory approach, especially working with local communities, is vital for their success. An assessment of the barriers to achieve LDN targets should be followed by concrete actions to overcome them. Pilot projects can form a second step, followed by the development of project proposals (co-designed with relevant stakeholders), which include logical frameworks, indicators, monitoring, evaluation, and reporting protocols. These pilots can enable the integration of LDN into strategic planning processes at (sub-) national levels, and the development of implementation plans and decision support systems.

LDN Target Setting Project in the Upper Sakarya Basin

The GEF-funded project, implemented by FAO in cooperation with the Ministry of Agriculture and Forestry, aims to develop a model for LDN target setting, planning, and implementation in the Upper Sakarya Basin (north-western Türkiye) for upscaling at the national level, and in line with Sustainable Development Goal Target 15.3.[25] The project was implemented according to a phased approach, first strengthening the enabling environment for LDN and multi-sectoral land use planning processes. This was followed by development of a decision support system for more sustainable land use that improves land cover and enhances soil carbon and productivity. This system facilitates the setting of LDN targets at the national level. As a result of the implementation of this project, the following global environmental and socio-economic benefits will continue to be generated:

- Increased spatial coverage of sustainable land and forest management practices on 14,000 hectares, divided evenly among forest, crop, and pasture lands
- Increased area under landscape-specific improvement plans totaling over four million hectares
- Improvements in the provision of ecosystem services, including annual increases in productivity of 10 to 25% and a reduction in soil erosion of two to six tonnes per hectare
- Increased LDN implementation at the national level covering 78.4 million hectares of land

Sustainable Land Management and Climate-Friendly Agriculture Project

The objective of this project is to integrate the sustainable management of agricultural, pasture, and forest lands in Konya to protect biodiversity and mitigate climate change by disseminating low-carbon technologies. The project aims to promote sustainable natural resource management practices and to develop cooperation mechanisms between the forestry and agriculture sectors. Activities focus on the rehabilitation of 30,250 hectares forest area, preparation of strategic and implementation plans, establishment of demonstration sites for various products and technologies, development of irrigation projects, and cooperation with universities and government institutions in the region.[26]

Murat River Watershed Rehabilitation Project

The project had a dedicated budget of over USD 51 million for afforestation, soil conservation, and rehabilitation, of which half was earmarked for poverty reduction.[27] The expected biophysical outcomes will be a 30% increase in vegetative cover in the 34 micro basins that form part of the project site encompassing 288,370 hectares. Also anticipated is a 20% decrease in soil erosion levels, a 30% decrease in annual firewood consumption per household, and an overall increase in ecosystem services productivity. Income-generating activities and the improvement of farm infrastructure account for half of the expenditure to date, with nearly 110,000 individuals, over 18,000 households, and 241 villages benefiting. Other expected outcomes are better living conditions (e.g., nutrition, income, workload) for 80% of participating families, including women and children involved in project planning and implementation, as well as a 20% increase in the number of households with access to irrigation water. The importance of gender in the project was highlighted by the fact that it received a Gender Equality Award in 2019. Many of these income-generating investments are targeted at livestock productivity and the added value of irrigated crops. In addition, government expenditure on compensating damage from natural disasters is expected to decrease by 10%.

Desertification Model and Vulnerability Map of Türkiye

Desertification Vulnerability Map of Türkiye displays a bio-geophysical quality as it was generated at national scale based on datasets related to seven criteria (ranked by order of importance, as climate, water, soil, land cover and land use, topography and geomorphology, socio-economy, and management) using the Analytic Hierarchy Process (AHP) method. The Desertification Vulnerability Map of Türkiye was revised in accordance with field studies carried out under Türkiye Desertification Model Verification and Calibration Project (TDM-VCP), covering the years 2016-2017.

Verification and calibration studies were successfully completed in basins, including the Gediz, Konya, Eastern Mediterranean, Yeşilırmak, and Euphrates-Tigris. Results of studies conducted in five plot sites revealed that the Desertification Model and Vulnerability Map of Türkiye resulted in 84% consistency with 90% confidence intervals at micro-basin scale. Along with these studies, in 2019, another calibration and validation study was performed in the Upper Sakarya Basin and this study resulted in 92.86% consistency with 95% confidence interval.

Soil Organic Carbon Project

With the Soil Organic Carbon Project, the organic carbon stock in Türkiye's soil has been determined and the necessary infrastructure has been prepared to manage the stock increase targets Türkiye has set as a country. More accurate decisions will be taken and effective policies will be developed with an approach where all public institutions and organizations working with soil will form a basis for their future activities and can predict the impact of their work on soil organic carbon stock.

Dynamic Erosion Model and Monitoring System

Türkiye gets results in combating soil erosion.[28] The amount of soil carried by rivers in Türkiye has been reduced to 154 million tonnes in 2018 from about 500 million tonnes per year in the 1970s, by afforestation activities, changes of irrigation techniques in agricultural areas, improvement of rangeland, and erosion control studies. The target is to reduce the number to 130 million tonnes in 2023.

ENDNOTES

1 https://www.unccd.int/sites/default/files/relevant-links/2017-01/ChangwonEval%20final%20report%20formatted_0.pdf

2 https://postconflict.unep.ch/publications/pcdmb_policy_01.pdf

3 https://www.unccd.int/news-events/unccd-ready-welcome-countries-new-peace-forest-initiative

4 https://www.feri-biodiversity.org/natural-regeneration

5 https://www.feri-biodiversity.org

6 http://www.fao.org/in-action/forest-landscape-restoration-mechanism/our-work/projects/kfs

7 United Nations Convention to Combat Desertification, 2019. The Global Land Outlook, Northeast Asia Thematic Report, Bonn, Germany.

8 Chinese Academy of Forestry and National Institute of Forest Science of ROK, 2019. Investigation and Ecological Benefits Evaluation of China and the Republic of Korea Afforestation Projects in China, 30 January 2019.

9 OECD, 2019. The Governance of Land Use in Korea: Urban Regeneration, OECD Publishing, Paris.

10 Kim, K., Križnik, B. and Kamvasinou, K., 2021. Between the state and citizens: Changing governance of intermediary organisations for inclusive and sustainable urban regeneration in Seoul. Land Use Policy, 105, p.105433.

11 Hayes, P., 2019. Building on Baekdudaegan: Peacemaking through Ecological Restoration. Global Asia, 14(4), pp.90-97.

12 Chung, M.Y., Son, S., Suh, G.U., Herrando-Moraira, S., Lee, C.H., López-Pujol, J. and Chung, M.G., 2018. The Korean Baekdudaegan Mountains: A glacial refugium and a biodiversity hotspot that needs to be conserved. Frontiers in genetics, 9, p.489.

13 Cho, W. and Chun, B.K., 2015. Restoration of the Baekdudaegan mountains in the Republic of Korea. Unasylva, 66(245), p.64.

14 The opinion of the central committee of the CPCC and the state council on construction of Ecological Civilization, State Council of China (In Chinese) 2015. http://www.gov.cn/xinwen/2015-05/05/content_2857363.htm

15 State Council unveils guideline on 'red lines' of spatial planning, China Daily, 08 November 2019. http://english.www.gov.cn/policies/policywatch/201911/08/content_WS5dc4c6bcc6d0bcf8c4c16bdb.html

16 Outline of the People's republic of China 14th Five-Year Plan for economic and social development and 2035 long range vision of for 2035, State Council of China, (In Chinese) March 2021. http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm, an English translation by Etcetera Language Group, Inc. Editor Ben Murphy, CSET Translation Lead at https://cset.georgetown.edu/wp-content/uploads/t0284_14th_Five_Year_Plan_EN.pdf

17 Master Plan for Major National Ecological System Protection and Restoration Projects (2021-2035). https://climatecooperation.cn/environment/policy-summary-on-the-master-plan-for-national-key-ecosystem-protection-and-restoration-major-projects-2021-2035

18 Wang, H., He, M., Ran, N., Xie, D., Wang, Q., Teng, M. and Wang, P., 2021. China's Key Forestry Ecological Development Programs: Implementation, Environmental Impact and Challenges. Forests, 12(1), p.101.

19 Xinhua, 2021 China makes notable progress on biodiversity conservation. 08 July. http://english.www.gov.cn/statecouncil/ministries/202107/08/content_WS60e63479c6d0df57f98dc919.html

20 Chen, C., Park, T., Wang, X., Piao, S., Xu, B., Chaturvedi, R.K., Fuchs, R., Brovkin, V., Ciais, P., Fensholt, R. and Tømmervik, H., 2019. China and India lead in greening of the world through land-use management. Nature sustainability, 2(2), pp.122-129.

21 Wu Ning, Chen Huai and Lu Tao, 2020. Building a community of life on earth: Chinese experience in ecosystem conservation and restoration. https://www.globaltimes.cn/content/1207141.shtml

22 Communist Party of China Central Committee and the State Council, 2021. China issues guideline on deepening reform of eco-compensation mechanism http://english.www.gov.cn/policies/latestreleases/202109/13/content_WS613e84cbc6d0df57f98e0140.html

23 https://web.ogm.gov.tr/lang/en/SitePages/OGM/OGMHaberler.aspx?List=8bd53a43%2D52b2%2D41db%2D80d0%2D43b-896d99784&ID=210&ContentTypeId=0x01001C1A7D5981F-3824BAEC330FC9EB79523

24 https://www.tika.gov.tr/en/news/breath_for_the_future_becomes_a_breath_for_the_world-59862

25 Contributing to Land Degradation Neutrality (LDN) Target Setting by Demonstrating the LDN Approach in the Upper Sakarya Basin for Scaling up at National Level. https://www.thegef.org/project/contributing-land-degradation-neutrality-ldn-target-setting-demonstrating-ldn-approach-upper

26 Sustainable land management and climate-friendly agriculture project. http://www.fao.org/dryland-forestry/projects/ongoing-projects/sustainable-land-management-and-climate-friendly-agriculture/en

27 IFAD, (n.d.) Murat River Watershed Rehabilitation Project. https://www.ifad.org/en/web/operations/-/project/1100001623

28 Dynamic Erosion Model and Monitoring System (DEMIS). https://www.unccd.int/news-stories/stories/turkey-gets-results-combating-soil-erosion

© alex-diaz-unsplash

GLOBAL LAND OUTLOOK WORKING PAPER SERIES

The GLO Working Papers Series is a supplementary set of publications that cover a wide variety of strategic issues related to land management, restoration, and planning. Several working papers were commissioned to provide insights and analysis on the major themes addressed in this second edition of the Global Land Outlook. The series is an ongoing activity that will contribute to future Outlooks.

LAND RESTORATION FOR POST COVID-19 RECOVERY

Baris Karapinar

FOOD SYSTEMS RESILIENCE AND LAND RESTORATION

Heather Elaydi

STRENGTHENING TENURE AND RESOURCE RIGHTS FOR LAND RESTORATION

Uchendu Eugene Chigbu, Menare Royal Mabakeng and Andrew Chilombo

YOUTH ENGAGEMENT IN LAND AND ECOSYSTEM RESTORATION

Sandra Delali Kemeh, and Alan Anis Mirhage Kabalan

GENDER AND LAND RESTORATION

Evelyn Namubiru-Mwaura

URBAN-RURAL LINKAGES AND ECOSYSTEM RESTORATION

Thomas Forster, Florence Egal, Camilo Antonio Romero Mera and Arthur Getz Escudero

REPURPOSING PERVERSE INCENTIVES FOR LAND RESTORATION

Adam Prakash

ECOLOGICAL CONNECTIVITY: AN ESSENTIAL COMPONENT OF ECOSYSTEM RESTORATION

Gary Tabor et al.

GLOBAL LAND OUTLOOK

The Global Land Outlook is the flagship publication of the United Nations Convention to Combat Desertification (UNCCD). It is supplemented by scenario analyses, regional thematic reports, and a working paper series. The objective of the UNCCD is to assist countries with the "rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions". The aim of the Global Land Outlook is to communicate and raise awareness of evidence-based, policy-relevant information to a variety of stakeholders, including national governments formulating their responses to commitments to better manage and restore land resources, including the SDGs and associated targets, such as Land Degradation Neutrality.

The first edition published in 2017 offered a global perspective on the intertwined drivers, risks, and impacts of desertification, land degradation, and drought. Since then, human-induced land degradation, water scarcity, biodiversity loss, and climate change continue to increase risk levels in food production and ecosystem services at times and in places where economic growth and stability is most needed. The second edition of the Global Land Outlook (GLO2) sets out the rationale, enabling factors, and diverse pathways by which countries and communities can reduce and reverse land degradation by designing and implementing their bespoke land restoration agenda. *Land Restoration for Recovery and Resilience* is about creating livelihood and development opportunities for people simply by changing the way we use and manage our land resources.

United Nations
Convention to Combat Desertification

United Nations Convention to Combat Desertification (UNCCD)

Platz der Vereinten Nationen 1
D-53113 Bonn, Germany
Tel: +49 (0) 228 815 2873

www.unccd.int