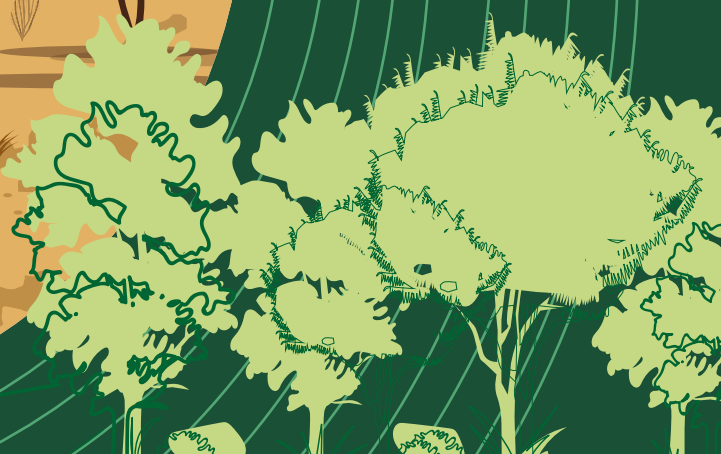
CGIAR

RESEARCH PROGRAM ON
Forests, Trees and Agroforestry

FTA HIGHLIGHTS OF A DECADE
2011-2021

Forest and Landscape Restoration

Ten years of forest, trees and agroforestry research in partnerships for sustainable development



About the FTA Highlights series

This publication is part of a series that highlights the main findings, results and achievements of the CGIAR Research Program on Forests, Trees and Agroforestry (FTA), from 2011 to 2021 (see full list of chapters on the last page).

FTA, the world's largest research for development partnership on forests, trees and agroforestry, started in 2011. FTA gather partners that work across a range of projects and initiatives, organized around a set of operational priorities. Such research was funded by multiple sources: CGIAR funders through program-level funding, and funders of bilateral projects attached to the programme, undertaken by one or several of its partners. Overall this represented an effort of about 850 million USD over a decade.

The ambition of this series is, on each topic, to show the actual contributions of FTA to research and development challenges and solutions over a decade. It features the work undertaken as part of the FTA program, by the strategic partners of FTA (CIFOR-ICRAF, The Alliance of Bioversity and CIAT, CATIE, CIRAD, Tropenbos and INBAR) and/or with other international and national partners. Such work is presented indifferently in the text as work "from FTA" and/or from the particular partner/organization that led it. Most of the references cited are from the FTA program.

This series was elaborated under the leadership of the FTA Director, overall guidance of an Editorial Committee constituted by the Management Team of FTA, support from the FTA Senior Technical Advisor, and oversight of the FTA Independent Steering Committee whose independent members acted as peer-reviewers of all the volumes in the series.

FTA HIGHLIGHTS OF A DECADE 2011-2021
Forest and Landscape Restoration

DOI: 10.17528/cifor/008214
Guariguata MR, Atmadja, S, Baral H, Boissière M, Brady M, Chomba S, Cronkleton P, Djoudi H, Duchelle A, Duguma L, Elias M, Gitz V, Graudal L, Harrison R, Ihalainen M, Jamnadass R, Jalonen R, Kassa H, Kettle C, Lawry S, Li Y, Locatelli B, Martius C, Meybeck A, Minang P, Murdiyarso D, Nawir A, Robiglio V, Sist P, Somarriba E, van Noordwijk M, Wardell A, Vågen T-G and Winowiecki L. 2021. *Forest and Landscape Restoration.* FTA Highlights of a Decade 2011–2021 series. Highlight No.4. Bogor, Indonesia: The CGIAR Research Program on Forests, Trees and Agroforestry (FTA).

CGIAR Research Program on Forests, Trees and Agroforestry
CIFOR Headquarters
Jalan CIFOR
Situ Gede, Sindang Barang
Bogor Barat 16115 Indonesia

T +62-251-8622-622
E cgiarforestsandtrees@cgiar.org

foreststreesagroforestry.org

We would like to thank all funding partners who supported this research through their contributions to the CGIAR Fund. For a full list of the 'CGIAR Fund' funding partners please see: http://www.cgiar.org/our-funders.

FTA HIGHLIGHTS OF A DECADE
2011-2021

Forest and Landscape Restoration

Lead Author: Manuel R. Guariguata

Contributing Authors:
Stibniati Atmadja, Himlal Baral, Manuel Boissière, Michael Brady, Susan Chomba, Peter Cronkleton, Houria Djoudi, Amy Duchelle, Lalisa Duguma, Marlène Elias, Vincent Gitz, Lars Graudal, Rhett Harrison, Markus Ihalainen, Ramni Jamnadass, Riina Jalonen, Habtemariam Kassa, Christopher Kettle, Steve Lawry, Yanxia Li, Bruno Locatelli, Christopher Martius, Alexandre Meybeck, Peter Minang, Daniel Murdiyarso, Ani Nawir, Valentina Robiglio, Plinio Sist, Eduardo Somarriba, Meine van Noordwijk, Andrew Wardell, Tor-Gunnar Vågen, and Leigh Winowiecki.

Editorial and publication team

FTA Highlights Support Team
Technical and scientific editing: Alexandre Meybeck, FTA senior technical advisor
Coordination of publication process, editing and lay-out: Fabio Ricci, FTA communications' coordinator
Coordination of the peer-review process: Monika Kiczkajlo, FTA program manager
Language editing and referencing: Patricia Halladay, consultant
Lay-out and design: Dharmi Bradley, consultant

Acknowledgements

Thanks are due to all the FTA scientists who kindly provided key relevant information and published material and useful insights, all of which facilitated the production of this publication.

We gratefully acknowledge Susan Braatz, Anne Marie Izac and Florencia Montagnini for their constructive review and feedback on an earlier version of the publication.

The final content remains the sole responsibility of the authors.

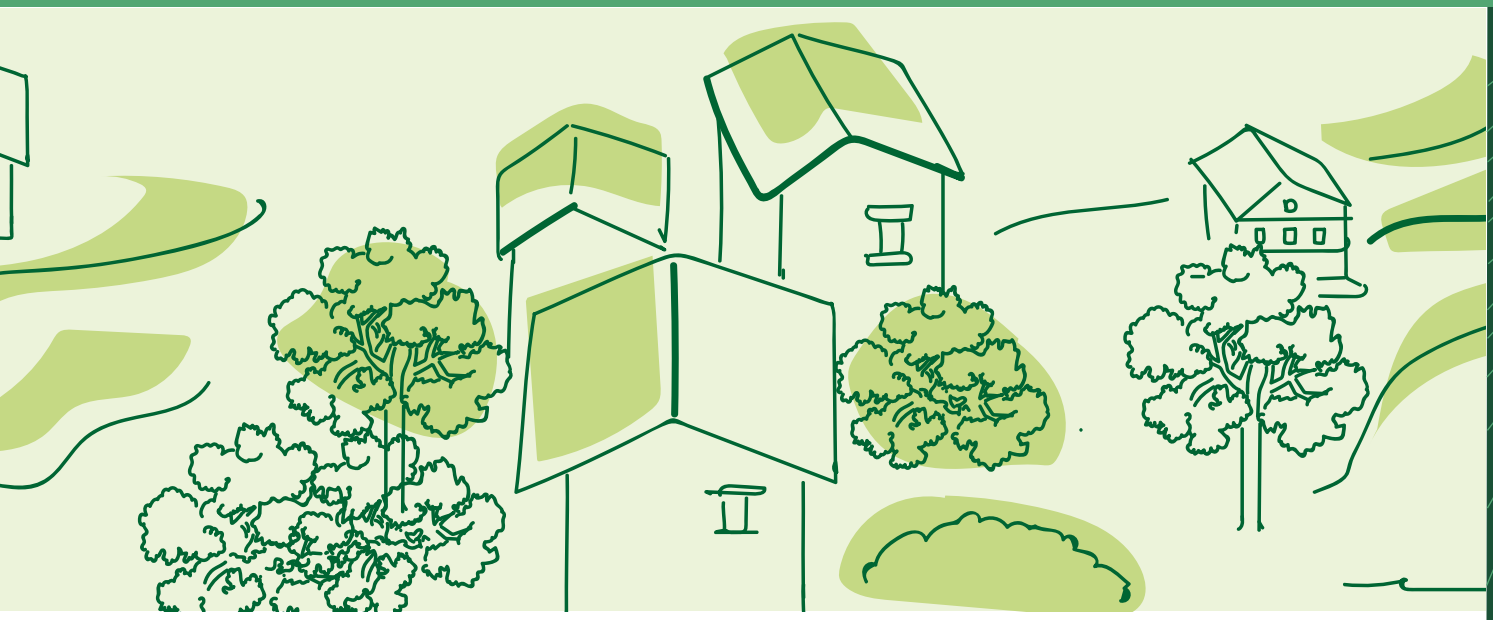
Table of contents

List of acronyms

CBD	Convention on Biological Diversity
CRP	CGIAR Research Programs
FAO	Food and Agriculture Organization
FLR	Forest and Landscape Restoration
FTA	CGIAR Research Program on Forests, Trees and Agroforestry
LDSF	Land Degradation Surveillance Framework
REDD+	Reducing Emissions from Deforestation and forest Degradation
SHARED	Stakeholder Approach to Risk Informed and Evidence-based Decision-making
TEER	The Economics of Ecosystem Restoration

Executive summary

Forest and landscape restoration (FLR) provides a framework for implementing restorative interventions that collectively address major environmental challenges such as soil and land degradation, biodiversity loss, water scarcity, lack of sustainable rural livelihoods, and climate change mitigation and adaptation. Restorative interventions can take many forms, which vary in cost, trajectory and specific economic and social outcomes; likewise, their benefits accrue to various actors and stakeholders. Over the last decade, the CGIAR Program on Forests, Trees and Agroforestry (FTA) has undertaken innovative basic and applied research across different scientific disciplines on the multiple dimensions of FLR for improving policy and practice and facilitating the uptake of new knowledge, tools and approaches — both from the top down and the bottom up. This publication presents key FTA outputs on forest and landscape restoration from 2011 to 2021. Many of them have contributed to informing the implementation of FLR interventions at multiple scales of work. These outputs are presented according to five broad areas of influence: (i) contributions to restoration science; (ii) contributions to global narratives and discourses; (iii) contributions to policy and governance; (iv) focusing on actors on the ground; and (v) contributions to national and international dialogues. The last section discusses ways to move forward.



1. Introduction

It is estimated that, at present, the well-being of at least 3 billion people is affected by unsustainable human activities, including natural habitat conversion and loss of land productivity (IPBES 2018). Millions of hectares (ha) across the global tropics need targeted restoration efforts that combine socioenvironmental benefits in a cost-effective manner (Brancalion et al. 2019) and support the livelihoods of local communities (Erbaugh et al. 2020). To this end, forest and landscape restoration (FLR), which includes not only forestry but the design and implementation of agroecological tools and approaches, aims to balance environmental and socioeconomic needs in the overarching objective of improving landscape functionality from a biodiversity conservation and production standpoint. Particularly over the last decade, there has been significant political and technical interest in implementing FLR as a way to restore forest and tree cover, regain soil and agricultural productivity, and conserve native habitat to enhance environmental values and improve human well-being. To date, more than 60 countries and jurisdictions have committed to restoring about 170 million ha under the Bonn Challenge[1] through the implementation of FLR initiatives. These commitments aim to contribute to meeting economic, social and environmental objectives. In addition, the recently declared UN Decade on Ecosystem Restoration 2021–2030 has as its overall goal to prevent and reverse the degradation of ecosystems worldwide through ambitious actions spanning many different sectors of society working in various spatial and temporal scales and socioecological contexts.

[1] See https://www.bonnchallenge.org/

In essence, the goal of FLR is to optimize environmental and socioeconomic needs and people's aspirations by combining various restoration activities within the landscape. These include promoting natural forest regrowth, establishing commercial tree plantations (as well as small-scale plantations for fuelwood) and agroforestry and agricultural systems, and conserving native ecosystems (all depending on context and local objectives; Figure 1).

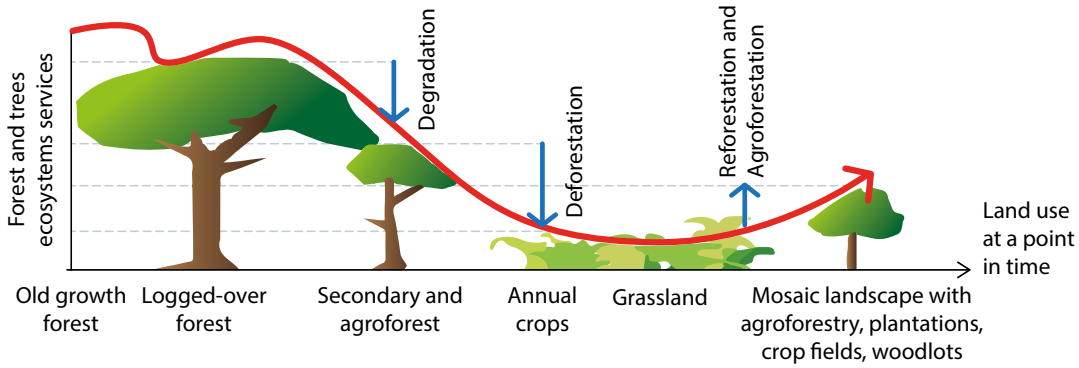


Figure 1. The "forest transition curve," along which restorative activities such as native habitat conservation, natural forest regrowth, commercial tree plantations, woodlots, enrichment plantings, and agroforestry systems are implemented along with soil restoration and conservation measures.

By building on the appropriate mix of these land uses across the landscape and balancing trade-offs, FLR aims further at providing environmental services, including conservation of biodiversity, carbon sequestration and hydrological regulation, while assisting people to adapt to climate change and become food secure. To this end, FLR draws from six internationally agreed principles (Besseau et al. 2018; see Table 1). Designing and implementing FLR requires the consideration of essential factors that, more often than not, cut across governance and jurisdictional scales: land tenure and access rights; multiple-stakeholder engagement and decision-making; enabling policy frameworks; socially (and gender-) inclusive planning, implementation and monitoring plans; adaptive management approaches; financial, human and biological resources; and technical and technological know-how, including traditional and cultural practices. Rather than being a goal, FLR is the means to achieve many goals.

Table 1. The six principles of forest and landscape restoration

1. Focus on landscapes	FLR takes place within and across entire landscapes, not individual sites, representing mosaics of interacting land uses and management practices under various tenure and governance systems. It is at this scale that ecological, social and economic priorities can be balanced.
2. Engage stakeholders and support participatory governance	FLR actively engages stakeholders at different scales, including vulnerable groups, in planning and decision-making regarding land use, restoration goals and strategies, implementation methods, benefit sharing, monitoring and review processes.
3. Restore multiple functions for multiple benefits	FLR interventions aim to restore multiple ecological, social and economic functions across a landscape and generate a range of ecosystem goods and services that benefit multiple stakeholder groups.
4. Maintain and enhance natural ecosystems within landscapes	FLR does not lead to the conversion or destruction of natural forests or other ecosystems. It enhances the conservation, recovery, and sustainable management of forests and other ecosystems.
5. Tailor to the local context using a variety of approaches	FLR uses a variety of approaches that are adapted to the local social, cultural, economic and ecological values, needs, and landscape history. It draws on latest science and best practice, and traditional and indigenous knowledge, and applies that information in the context of local capacities and existing or new governance structures.
6. Manage adaptively for long-term resilience	FLR seeks to enhance the resilience of the landscape and its stakeholders over the medium and long-term. Restoration approaches should enhance species and genetic diversity and be adjusted over time to reflect changes in climate and other environmental conditions, knowledge, capacities, stakeholder needs, and societal values. As restoration progresses, information from monitoring activities, research, and stakeholder guidance should be integrated into management plans.

2. Background

Since its creation in 2011, the same year the Bonn Challenge was launched (Figure 2), the CGIAR Research Program on Forests, Trees and Agroforestry (FTA) has played an important role in shaping the global restoration agenda. This includes a variety of products: innovative approaches to design, implement and monitor FLR interventions; production of scientific evidence and perspectives on controversial issues, and development of conceptual and assessment frameworks; and diagnostics to guide restoration policy and practice. Although conceptualizing, implementing and monitoring FLR remains challenging due to its multifaceted nature (which includes political, economic, social and biophysical dimensions), the FTA Program has helped to overcome some of these challenges by providing essential entry points for researchers, practitioners and decision makers — both from the top down and the bottom up — across a range of disciplines. As FTA comes to a close, the many different outputs highlighted in this publication are expected to further influence the implementation of the UN Decade on Ecosystem Restoration 2021–2030.

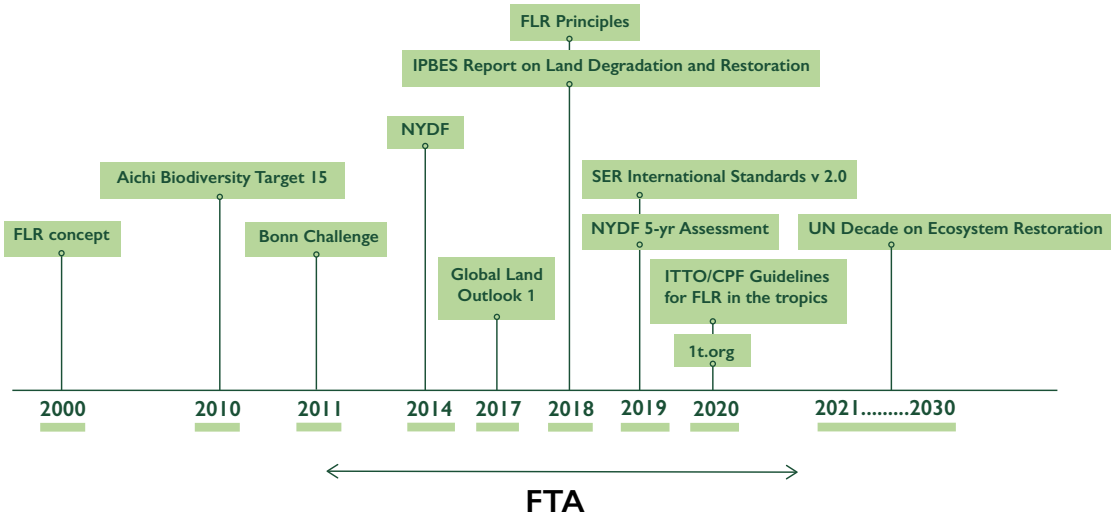


Figure 2. Key milestones in the context of the global restoration agenda influenced by FTA work

In Phase 1 of FTA,[2] the restoration theme focused on efforts to reverse degradation and improve landscape management for environmental services, biodiversity conservation and livelihoods. The first independent evaluation of FTA in 2014 (CGIAR-IEA 2014) found that further strengthening research on the restoration of degraded lands was required. This recommendation was taken into account in the preparation of Phase 2 of FTA,[3] which included forest and landscape restoration as part of the FTA Flagship Program on landscapes and the Flagship Program on genetic resources. The creation of FTA's Priority on Restoration in 2017 further emphasized FLR as a distinct area of research organized around three domains: the "how" of restoration (practices, tools, methods); the economics of restoration; and the governance of restoration, all of which are reflected in this document.

This publication highlights key FTA outputs on forest and landscape restoration over the last decade that have informed FLR science, policy and practice. These outputs are presented according to five broad areas of influence: (1) contributions to restoration science; (2) contributions to global narratives, strategies and discourses; (3) contributions to policy and governance; (4) focusing on actors on the ground; and (5) contributions to international and national dialogues. The publication ends with conclusions and forward-looking thoughts.

[2] Phase 1 of FTA was known as CRP6. See CGIAR Research Program 6, Forests, Trees and Agroforestry: Livelihoods, Landscapes and Governance. Proposal. CIFOR. February 2011.
[3] See CGIAR Research Program on Forests, Trees and Agroforestry. Revised Phase II Full proposal 2017–2022. 31 July 2016.

3. Contributions to restoration science

FTA scientists have contributed significantly to influencing the scientific underpinnings of FLR, from the local to the national and the global levels; and from basic knowledge production to the generation of tools to enable and facilitate FLR, including remote-sensing applications and participatory approaches. Over the last decade the scientific links between FLR and climate change mitigation and adaptation, food security, and nutrition and poverty alleviation have been made further apparent through FTA's work for improved restoration policy and practice.

The science underlying FLR can be subject to controversies, some of which FTA endeavoured to disentangle. Among these is the relation between large-scale tree planting and water availability at different scales. There are still many misconceptions and insufficient applied knowledge to elucidate to what extent, and under which environmental conditions, tree planting affects water availability. This was summarized in a state-of-the-art report in which FTA researchers participated (Creed and van Noordwijk 2018). The science of tree-water interactions is particularly relevant in regions with a pronounced dry season and that are solely dependent on rainfed water. FTA scientists and collaborators demonstrated that in West African woodlands, groundwater recharge was maximized at moderate tree cover, in contrast to the conventional wisdom that recharge would be optimal with no trees

planted (Ilstedt et al. 2016). This research offers important implications for tree-planting initiatives that, if carefully designed, can benefit local livelihoods in seasonally dry ecosystems.

On the same topic, FTA scientists carried out a systematic review of the impacts of forestation on water supply, hydrological regulation and mitigation of erosion and landslides across catchments within the Andean region. Besides pointing out that reforestation and/or afforestation reduced erosion of soils and decreased the risk of moderate floods, the review concluded that tree planting in native, high-elevation treeless ecosystems had detrimental consequences on water yields (Bonnesoeur et al. 2019). At much larger spatial scales, a highly influential FTA paper further raised awareness of the fact that the enhancement of hydrological services via tree planting and/or native forest conservation may potentially benefit and affect people who are hundreds if not thousands of kilometres away; that is, very far from

Landscape in the Kongoussi area, Burkina Faso.

Photo by Ollivier Girard/ CIFOR

where any decisions on tree planting or removal are usually made (Ellison et al. 2017). These findings have important implications for food security, as many key grain-basket areas are rain-fed and depend on remotely generated rainfall. FTA has also contributed to the debate of where to plant trees by emphasizing the need to consider the influence that trees exert on local and regional hydrology (Sheil et al. 2019), as well as discerning when and where to rely on natural forest regrowth (i.e., passive approaches) versus tree planting (Guariguata 2019 et al.; Chazdon et al. 2020b; Lohbeck et al. 2020).

Ugwono Pauline plants Gnetum (okok) in the village of Minwoho, Lekié, Center Region, Cameroon.

Photo by Ollivier Girard/CIFOR

Forest and landscape restoration is intimately linked to climate change mitigation and adaptation by enhancing landscape productivity and ecosystem resilience and reducing the vulnerability of forest-dependent people and local communities. This required FTA to look across a wide range of scientific fields in order to understand relationships within socioecological systems and the various kinds of impacts of FLR, and to study trade-offs and synergies between these relationships and between FLR and other integrated landscape approaches. FTA scientists have carefully examined and discussed the links between climate mitigation and adaptation in the context of FLR by focusing less on carbon storage (Locatelli et al. 2016). FTA has highlighted in co-publications with FAO (Meybeck et al. 2019; Meybeck et al. 2020) how habitat degradation increases the vulnerability of forests and forest-dependent people to climate change and how FLR can contribute to adaptation to climate change as part of national adaptation plans.

One key message that has long resonated in restoration policy and practice, from the national to the global level, is that adaptation to and mitigation of climate change should not be considered separately. Yet they remain often divorced in terms of sectoral mandates, legal and normative frameworks and climate finance mechanisms, and adaptation actors remain not well informed about mitigation actions and vice versa. FTA scientists have taken an innovative approach to this issue through detailed analyses of social networks. The study showed that national government actors were overrepresented, that mitigation was predominant over adaptation, and that the actor groups who were relevant to implementing policy were isolated from each other (Locatelli et al. 2020). FTA has also elevated in the global restoration agenda the importance of synergies between climate mitigation and adaptation actions through the concept of climate-smart landscapes, which aims to optimize the contribution of trees, agroforests and forests to both livelihood and environmental benefits (Minang et al. 2015) while raising awareness of the need to approach FLR through an integrated, socioecological adaptation perspective in the face of climate uncertainty (Pramova et al. 2019). In addition, FTA work has produced detailed knowledge on carbon recovery time in selectively logged tropical forests in order to influence policies governing management practices while informing forest-based climate change mitigation interventions (Rutishauser et al. 2015; Piponiot et al. 2016).

4. Contributions to global narratives, strategies and discourses

Since the start of the Bonn Challenge, FTA contributions have helped to promote coherence in the global restoration agenda by providing updated syntheses, standards of practice, diagnostic frameworks and practical guidance for designing, implementing and monitoring FLR projects and programs.

4.1 Conceptual, monitoring and assessment frameworks and technical guidance

In 2018, FTA scientists participated in the production of the second edition of the International Principles and Standards for the Practice of Ecological Restoration (Gann et al. 2019). The Standards provide a holistic framework for restoration projects to achieve their intended goals, ensure more effective outcomes from projects and programs, increase cost effectiveness and accountability, and reduce investors' risk. Drawing substantially on the Standards, the Forest Stewardship Council (FSC), also with input from FTA scientists, drafted a new procedure to remediate past forest conversion.[4] Once this procedure is eventually adopted by the FSC General Assembly, it could

[4] See https://jp.fsc.org/preview.fsc-policy-on-conversion.a-588.pdf

lead to substantial restoration efforts that could be further financed by the forestry and timber sector.

In 2019, FTA experts took part in an initiative, led by the International Tropical Timber Organization and the Collaborative Partnership on Forests, to develop a revised version of the Guidelines for Forest Landscape Restoration in the Tropics (ITTO 2020) that operationalizes the six FLR principles (Table 1) into actions on the ground. The guidelines are intended to serve as a coherent framework for FLR design, implementation and monitoring. FTA also conducted, as part of its collaboration with CGIAR's Research Program on Policies, Institutions and Markets, and Research Program on Water, Land and Ecosystems Program, a joint assessment of CGIAR work on FLR (Gitz et al. 2020a). Drawing from this work, a typology of restoration options to support decision making was produced (van Noordwijk et al. 2020). The typology assists those implementing FLR interventions to do so in a socially inclusive manner along various stages of the "forest transition curve"[5] (Figure 1).

FTA has also contributed to the generation of international guidance for managing and restoring degraded ecosystems, focusing in particular on bamboo, a multipurpose plant with a wide range of high-end industrial products. The planting of bamboo contributes to land restoration through its fast growth rate and ability to stabilize eroding slopes while providing economic benefits. However, it has also raised concerns vis-à-vis its environmental and social acceptability, especially for exotic bamboo species. A 2019 manual provides up-to-date information for the establishment and management of bamboo plantations, all the way from the nursery to the harvesting phases (Durai and Long 2019). At the national level, management guidance on bamboo was also produced for Ethiopia (Boissière, Beyessa and Atmadja 2019) in support of the government's current plans to develop the bamboo sector. Likewise, FTA crafted guidelines for dry forest management adapted to the Ethiopian context (Atmadja et al. 2019) as a response to that country's government making sustainable management of dry forests a priority that includes reforestation actions. Similarly, FTA has also raised international awareness through detailed, multi-country data collection across Africa on the need to pay careful attention to the local context as a key precondition for inclusive upscaling of regionally-based FLR initiatives (Hughes et al. 2020).

[5] The forest transition curve describes over time a reversal or turnaround in land-use trends for a given territory from a period of net forest area loss to a period of net forest area gain (i.e., tree plantations or natural forest regrowth).

FTA scientists have further developed innovative diagnostic and assessment tools to help in the design, implementation and monitoring of FLR. Based on analyses of historical experiences with FLR, a "stoplight" tool to evaluate, design, monitor and communicate FLR has been developed (Stanturff et al. 2015). A collaborative monitoring diagnostic (Guariguata and Evans 2020) assists FLR planners to assess their initiatives against a checklist of success factors to determine whether they are ready for collaborative monitoring and to identify what elements need to be strengthened across a range of jurisdictional scales. A tenure-responsive diagnostic (McLain et al. 2021) offers restoration practitioners a framework for identifying the policy reforms needed to address rights-related barriers to FLR design and implementation. A framework to assess the provision of ecosystem services from planted forests (Baral, Guariguata and Keenan 2016) aims at helping managers and implementers to identify and measure both the delivery of a given service and the intended beneficiaries of it. This framework has inspired FTA partners such as WWF New Generation Plantations Initiative[6] and has been tested on the ground in tree plantations (Paudyal et al. 2020), adapted to bamboo forests in particular (Paudyal et al. 2019). FTA work has also contributed to developing conceptual frameworks for socially inclusive and ecologically sound peatland restoration in Indonesia (Puspitaloka et al. 2019).

FTA scientists and partners have developed innovative geospatial tools and approaches such as the Land Degradation Surveillance Framework (LDSF) to diagnose land and soil health across landscapes.[7] The framework aims at enhancing understanding of land degradation dynamics at multiple spatial scales and is continuously fed by collecting data through a rigorous sampling process of a number of indicators of soil and land integrity. The LDSF has been applied in projects across the global tropics (Vågen et al. 2016; Vågen et al. 2013; Vågen and Winowiecki 2019) and is currently one of the largest global land health databases, with more than 30,000 plot observations and a soil property database with data from more than 100,000 soil samples. Key outputs from the framework include approaches to assess restoration potential in African drylands (Winowiecki et al. 2018), participatory approaches to assess degradation and prioritize restoration actions (Crossland et al. 2018), and assessments of soil-based climate mitigation potential (Vågen and Winowiecki 2013).

FTA also hosts and regularly updates the collaborative International Database on REDD+ projects and programs,[8] which includes restoration/afforestation projects as part of the + (plus) in REDD+. Globally, there

[6] https://newgenerationplantations.org/multimedia/file/ff98c77e-77cb-11e3-92fa-005056986314
[7] http://landscapeportal.org/blog/2015/03/25/the-land-degradation-surveillance-framework-ldsf/
[8] http://www.reddprojectsdatabase.org/

Bag of charcoal being transported to the market, Yangambi, DRC.

Photo by Axel Fassio/CIFOR.

is continued interest in the database, which to date has been used widely and cited in dozens of scientific publications. FTA has also developed an assessment tool to determine the vulnerability of selected tree species in South American dry forests to anthropogenic threats (including climate change, fire and overexploitation) in order to inform both restoration and conservation planning (Fremout et al. 2020).

Finally, FTA scientists and partners have developed two mobile tools for farmers and restoration practitioners to "plant the right tree in the right place for the right purpose" and to collect information on how farmers are managing and protecting trees on their farms. One is the **vegetationmap4africa** (Lillesø et al. 2011; van Breugel et al. 2015), a tool that provides information about those species that can potentially occur in any selected location, based on their documented occurrence in different natural vegetation types.[9] The other is the **Regreening Africa App**, which helps users to collect information on how farmers are managing and protecting trees on their farms.[10] The high resolution baseline potential natural vegetation map for Eastern Africa (http://vegetationmap4africa.org) is also integrated in the Ecoregions 2017 (http://ecoregions2017.appspot.com/) map (Dinerstein et al. 2017) that was utilized to investigate the potential of allocating at least half of the Earth to conservation.

[9] https://vegetationmap4africa.org/Home.html
[10] https://play.google.com/store/apps/details?id=com.icraf.gsl.regreeningafrica

4.2 FLR and gender

Gender equality and social inclusion cuts across the FTA portfolio through a multicentre Gender Integration Team. The team has played an important role in raising the profile of gender within forest and landscape restoration among various environmental organizations and actors at different levels. This includes organizing an international workshop at the Global Landscapes Forum in 2017, where discussions on lessons learned and knowledge-sharing exchanges took place among civil society, multilateral organizations, the research community and private-sector actors. A set of proposals was prepared on how to enhance gender responsiveness in FLR initiatives.[11] In the same year, the team produced a framework for the design and implementation of FLR interventions that included a series of recommendations for advancing gender equality and justice in these interventions, also identifying the main risks involved when gender issues are ignored (Basnett et al. 2017). The framework has been used by key FTA partners[12] and further integrated into FLR guidance.[13] Gender issues in the context of participation, empowerment and benefit sharing have also been addressed by FTA scientists in the monitoring FLR activities (Evans et al. 2018; Mwangi et al. 2011) and the practice of agroforestry (Kiptot et al. 2014).

[11] https://www.globallandscapesforum.org/publication/joint-infobrief-set-on-gender-equality-and-forest-landscape-restoration/
[12] Partners include United Nations Convention to Combat Desertification, Women Organizing for Change in Agriculture and Natural Resource Management, and International Union for the Conservation of Nature
[13] See https://www.recoftc.org/flr-guide-southeast-asia/why-and-how-should-we-consider-gender-equality-forest-landscape-restoration

4.3 Bioenergy and food security in FLR

In many landscapes where forest and landscape restoration is being proposed, contributions to energy security through bio-energy pathways are rarely highlighted as an important FLR intervention. In addition, concrete guidance on how to mitigate the impact of bioenergy production, which includes woodfuel, in a landscape context remains largely unaddressed. FTA scientists have helped to raise awareness of the technical (Harvey and Guariguata 2020) and governance dimensions of woodfuel production and use by recommending integrated approaches that enhance local livelihoods (Sola et al. 2016) while also contributing to the food security of rural populations, especially in remote areas that are off-grid (Mendum and Njenga 2018). Further, FTA scientists have highlighted the role that agroforestry can play in reducing wood harvest pressures in forests through supplying trees on farms (Liyama et al. 2016). FTA scientists have also generated evidence on the contribution that bioenergy crops make to meeting the requirements for energy and food security while restoring degraded land (Rahman et al. 2019). Recent FTA work across the African continent, where biomass-based energy will maintain its importance in the near future, assessed the role of FLR for bioenergy purposes while demonstrating its high potential for minimizing native forest loss and habitat degradation (Duguma et al. 2020). From a food security perspective, FTA scientists also have raised awareness of how the extraordinary diversity of tropical tree species is often insufficiently integrated into food systems, while proposing key interventions to increase the consumption and production of tropical tree-sourced foods as a restoration option (Jamnadass et al. 2014; Jansen et al. 2020).

4.4 Clarifying the "L" in FLR

Over the last decades, it has become increasingly clear that conventional sectoral approaches, often interconnected and at times conflicting, to address environmental and social problems remain inadequate to tackle biodiversity, climate and food security challenges. The need for integrated and transdisciplinary approaches, often described as a "landscape approach," is embedded in the overall goal of forest and landscape restoration: to regain ecological functionality and enhance human well-being across deforested or degraded landscapes and to manage competing land uses and societal aspirations in an integrated fashion.

Although it remains challenging to implement a landscape approach in practice, FTA scientists have worked collaboratively on the design and implementation of this approach in the context of FLR (Chazdon et al. 2020a). They have further developed key principles and conceptual approaches for implementing landscape approaches (Sayer et al. 2014; Freeman et al. 2015) and added further elements on how to improve them (Reed et al. 2016), while also developing novel ways for measuring holistic, landscape-level outcomes (Reed et al. 2020). All these efforts will be put to practice through the Engagement Landscapes concept, where long-term work aims at supporting transformational change and enhancing landscape resilience. Engagement Landscapes, in discrete geographic areas in South America, Africa and Asia, are an integral component of the 2020–2030 CIFOR-ICRAF Strategy (CIFOR-ICRAF 2020). They are meant to capture the critical dimensions needed to design and implement FLR interventions, among others, that include political economy, governance, policies and the needs of various stakeholders and social groups (Watson 2020).

The village of Nalma, Nepal, in the foothills of the Himalayas.

Photo by Mokhamad Edliadi/ CIFOR.

4.5 The right genes and the right species

CIFOR scientist recording the measurement of a sapelli tree near Lieki, DRC.

Photo by Axel Fassio/ CIFOR

Failing to consider genetic issues before selecting plant material for restoration purposes may result in poor growth and survival and ultimately, in a waste of both human and financial resources, regardless of the original objectives (e.g., biodiversity conservation, carbon sequestration or timber production). Seminal reports on this topic produced in part by FTA (e.g., Bozzano et al. 2014; Loo et al. 2014) ultimately generated a series of research, management and policy recommendations that were disseminated, in particular, at regional training workshops led by the Secretariat of the Convention on Biological Diversity (CBD) in 2014 in the context of its ecosystem restoration mandate (Aichi Target 15).[14] As a result, the Conference of the Parties to the CBD adopted a recommendation in the same year to include genetic considerations in ecosystem restoration and conservation.[15] Since then, FTA scientists have been active in further raising international awareness of the need to pay attention to the quality and genetic diversity of seeds. Global assessments of ongoing FLR initiatives worldwide (Jalonen et al. 2018) and climate mitigation projects (Roshetko et al. 2018) identified a critical lack of sufficient genetic diversity of tree germplasm, while a detailed baseline assessment across seven Latin American countries reinforced the need to pay much more attention to the genetic origin and diversity of seeds used in reforestation programs and projects (Atkinson et al. 2018). An FTA paper (Lillesø et al. 2018) analyses reasons for and suggests measures to mitigate the lack of adoption in productive systems and for FLR.

The species selection tool based on the **vegetationmap4africa** (Kindt et al. 2015) and the Diversity for Restoration tool[16] goes even further. The latter focused on dry forest ecosystems in tropical America, and the former on areas of Africa, aims at assisting managers, researchers and decision makers in selecting the most appropriate tree species, along with the best source of seeds, for a given restoration objective, and includes information about tree propagation and climate change considerations (Thomas et al. 2017). More recent FTA work has delved deeper into the seed-supply dimension of FLR to discern the factors that either promote or hinder the supply of good-quality and site-adapted tree seeds, in order to further identify key entry points for inserting high-quality germplasm in a FLR context (Valette et al. 2020; Lillesø et al. 2018 and 2021).

[14] https://www.cbd.int/sp/targets
[15] See CBD COP Decision XII/19. https://www.cbd.int/decisions/cop/12/19
[16] https://www.diversityforrestoration.org/

5. Contributions to policy and governance

Policy agendas are generally the product of a political process and often develop with little input from researchers and experienced practitioners, who generate relevant knowledge. At the same time, research agendas are often developed without the participation of policymakers and therefore may not be relevant to key policy issues. Knowledge-generation projects, regardless of their funding sources and the origins of investigators, need to ensure that information can be transferred to relevant stakeholders. Over the years, FTA scientists and partners have aimed to bridge this gap by targeting research to influence policies and regulations in the context of FLR interventions, through national and regional assessments of both past and existing initiatives in the context of planning, implementing and monitoring biophysical and socioeconomic dimensions.

5.1 Looking back to move forward: identifying gaps in FLR policies, programs and projects

The launch of the Bonn Challenge in 2011 and related initiatives at the regional level (i.e., AFR100 for Africa, Initiative 20x20 for Latin America) triggered the development of national restoration plans and strategies. FTA scientists examined the scope and contents of some of these plans while also looking at lessons learned from past efforts in shaping national restoration

ambitions. A comparative analysis of four national restoration plans from Latin America (Méndez-Toribio et al. 2017) revealed critical gaps that warrant attention in order to upscale restoration efforts and meet national and international commitments, including paying more attention to social participation and to adaptive management and monitoring. A comprehensive analysis of lessons learned from restoration initiatives in Colombia over the last four decades (Murcia and Guariguata 2014) provided recommendations for governments, managers and researchers on how to overcome design and implementation challenges for greater impact. These recommendations came at the right time: just when the Colombian national restoration plan was being developed in 2015 and are still considered in the design of current tree planting programs in this country. In China, FTA scientists examined the effectiveness of compensation payments in large-scale restoration efforts such as the Conversion of Cropland to Forests Program (Bennett et al. 2014). A similar assessment for Mexico looked into the successes, lessons learned, and research and development gaps and will inform the development of the national restoration plan (Méndez-Toribio et al. 2018). From the standpoint of commercial tree plantations, and recognizing a knowledge gap in Peru's forest plantation sector, FTA and partners conducted a historical analysis of country-specific data to learn from the past, identify specific bottlenecks, and detail the building blocks Peru could use for long-term planning. The resulting report (Guariguata et al. 2017) greatly influenced Peru's Forest Service in the development of its plantation forest program by providing recommendations to formulate its response to the country's restoration-plantation challenge.

Bolaina (*Guazuma crinita*) plantation in an agroforestry system, Peru.

Photo by Juan Carlos Huayllapuma/ CIFOR

Ethiopia, a country with important domestic commitments to forest and landscape restoration, has been a key location for intensive FTA work on FLR. A nationwide project-level characterization in that country (Abera et al. 2019) concluded that historically, most FLR research has focused at the plot scale, thus constraining the ability to influence wider, landscape-scale processes and associated socioecological interactions; and that many of the FLR initiatives were sectoral in nature. Over the years, FTA scientists and partners have actively engaged with decision makers in Ethiopia on how to enhance national forest legislation as it pertains to FLR issues; in particular, on recognizing community rights to forest use (McLain et al. 2019), and to address a key bottleneck of appropriate planting material for restoration (Lillesø et al. 2018 and 2021). FTA researchers have also looked at participatory forest management and area exclosure — the two major FLR interventions applied in Ethiopia — by identifying and proposing the key actions needed for improving their social and environmental outcomes (Kassa et al. 2017).

At the regional level, FTA scientists have concentrated much effort in Latin America on various fronts. They assessed the extent to which ongoing land restoration projects are contributing to satisfy the multiple goals embedded in the FLR approach as a way to guide and improve scaling up while assessing implementation gaps (Coppus et al. 2019). A key finding is that, despite growing awareness that integrated approaches are at the heart of FLR, the socioeconomic dimension remains under-addressed in the majority of restoration projects. In addition, monitoring — also key in order to learn from FLR approaches and their results over time — is still regarded as an extra cost instead of a necessary investment. FTA gauged the perceptions of different types of stakeholders from 17 countries of how forestry and environmental legal frameworks enabled or hampered the effective implementation of FLR interventions at the national level (Schweizer et al. 2021a). The authors found that most legal frameworks are in sectoral "silos" and that, as a whole, these frameworks lacked much-needed articulation to enable the coordinated deployment of FLR interventions across landscapes. Another study (Cronkleton et al. 2017) examined the clarification and securing of local stakeholders' property rights as one incentive for FLR. It also showed how policy reforms have influenced local participation in FLR initiatives by modifying land-use behaviour to increase forest cover. Finally, another multicountry report provided key policy recommendations and common lessons learned in optimizing the role that bamboo plays in restoring degraded lands, drawing on locally developed, bamboo-based FLR initiatives (FAO and INBAR 2018).

5.2 Policy and legal levers to promote natural forest regrowth

Under suitable conditions, deforested land used for agricultural crops or pastures can revert to forest through assisted or unassisted natural regeneration. Natural regeneration can sometimes be a preferable, complementary activity to tree planting by virtue of its cost effectiveness and biodiversity values. FTA researchers have discerned key research and policy-related aspects that include identifying biophysical and socioeconomic drivers for (assisted and/or unassisted) natural forest regrowth to prosper as a viable land-use option (Lohbeck et al. 2020; Crouzeilles et al. 2020); information on monitoring approaches involving local communities (Evans et al. 2018); and highlighting the main enabling incentives, governance structures and regulatory conditions needed to promote the stewardship of natural forest regrowth (Chazdon et al. 2020b). In the Peruvian Amazon, for example, although farmers rely on natural forest regeneration to promote the establishment and growth of fast-growing timber, forestry legal frameworks often hamper the use, harvesting and transport of trees from agricultural fallows. FTA work has generated recommendations to national forestry authorities to include fallow timber in farm and forest regulations in order to help formalize the supply chain and generate economic benefits to small-scale producers (Sears et al. 2018). Also in Peru, after assessing the potential role of agroforestry concessions in maintaining and enhancing tree cover, FTA researchers recommended to forestry authorities to revise existing regulations to formally recognize local agroforestry practices (Robiglio and Reyes 2016).

6. Focusing on actors on the ground

Previous national assessments by FTA and partners revealed that, overall, there was little involvement of local communities in the design and monitoring of restoration projects (Murcia and Guariguata 2014; Méndez-Toribio et al. 2018). Entities that adopt top-down approaches are unlikely to gain the community support and ownership needed for long-term sustainability. However, FLR interventions require approaches that are practical and suited to larger scales, which often means embracing a wide variety of contexts in the landscape. To this end, appropriately moving beyond the plot scale is essential for upscaled solutions. The Research in Development approach developed by FTA and partners relies on strong farmer participation in the design and implementation of restoration projects across a diverse number of sites and socioecological contexts. In this way, any variations in local conditions and farmer circumstances are explicitly included in the research to generate evidence for upscaling and large-scale impact; that is, understanding what works best where and for whom. Under this framework, a farm-centred project,[17] implemented in Ethiopia, Kenya, Mali and Niger, has influenced the adoption of restoration practices on the ground (Mollins 2020) while also explicitly including gender dimensions (Crossland and Paez-Valencia 2020) and applying innovative co-learning and knowledge-sharing approaches (ICRAF 2020).

[17] The project was the Restoration of Degraded Land for Food Security and Poverty Reduction in East Africa and the Sahel: taking successes in land restoration to scale. See http://www.worldagroforestry.org/output/full-brochure-2020-using-planned-comparisons-east-africa-and-sahel

From both an operational and a capacity development standpoint, scaling FLR from the bottom up is necessary yet challenging. How to bring together teams with the adequate disciplinary backgrounds (forestry, ecology, economics, as well as social and political science) remains an important consideration. Gaps in professional capacity development have been identified by FTA and partners by surveying more than 400 restoration professionals across Latin America and the Caribbean (Meli et al. 2019). The study concluded that the most important constraint hindering FLR capacity development is the limited availability of both curricular and extra-curricular programs, most notably, short intensive courses focused on socioeconomic and management dimensions. Further, a negotiation-support toolkit for learning landscapes was published by FTA scientists (van Noordwijk et al. 2013); the book showcases 49 methods and computer software that allow rapid appraisals to be conducted of landscapes, conflict over land tenure, markets, hydrology, agrobiodiversity and carbon stocks, and to run simulation models at various scales (for example, tree and crop interaction at the plot level, water flows in landscapes, land-use-change dynamics) that can be used to combine broad insights with the specific properties of any location. On-the-ground approaches for inclusiveness in restoration decision making have been also pioneered by FTA, such as the Stakeholder Approach to Risk Informed and Evidence-based Decision-making (SHARED).[18] It provides a framework to bring together processes, evidence and tools, and to shift decision making towards more inclusive, inter-sectoral and inter-institutional integration, applied through FTA's Engagement Landscape approach.

6.1 Economics of restoration

FTA has identified cost-benefit analysis as an area that needs additional research to facilitate the engagement of actors, particularly investors for up-scaling (Wainaina et al. 2020; Gitz et al. 2020b). It participates in The Economics of Ecosystem Restoration (TEER) initiative led by FAO, which has developed a protocol to collect standardized data on the costs and benefits of restoration projects.

The potential of markets and their interaction with policies to leverage investment for FLR in the tropics remains a challenge. In particular, governments will need to play a critical role in establishing appropriate policy frameworks and institutional arrangements to support private investments for upscaling FLR initiatives. FTA researchers assessed the effectiveness of

[18] http://www.worldagroforestry.org/shared

restoration concessions in Indonesia; created in 2004, they remain the largest initiative to restore tropical forests through private investment (Harrison et al. 2020). Although they provide a promising approach, the study revealed that implementation costs remain high, and that developing revenues at sufficient scale from carbon, non-timber forest products and ecosystem services remains challenging. The results of this work have prompted the review of the regulatory framework governing restoration concessions in order to make them more investor-friendly.

Forest nursery, West Kalimantan, Indonesia.

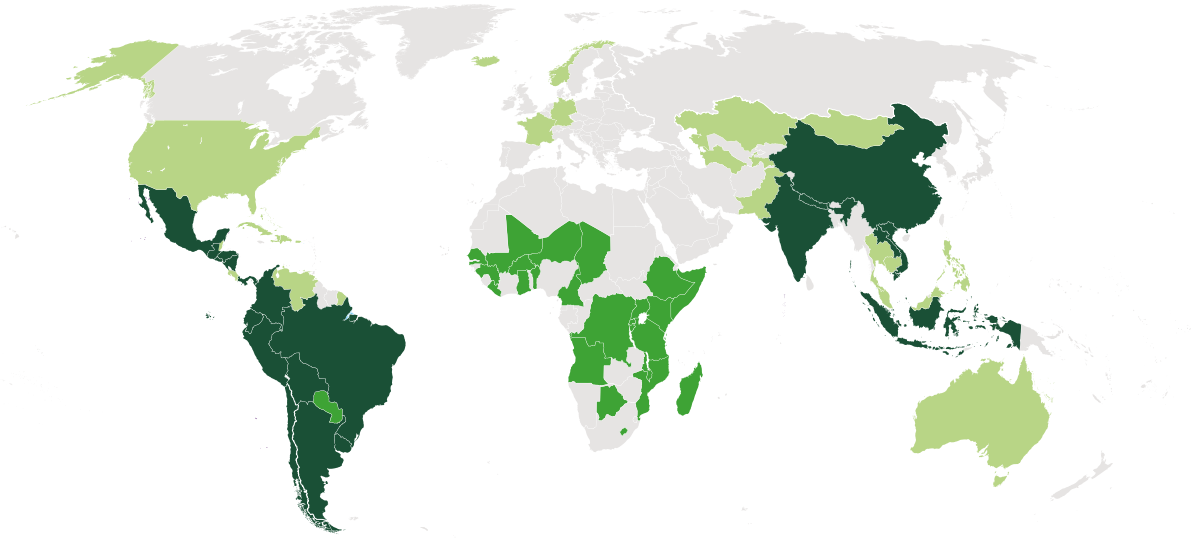
Photo by Ricky Martin/CIFOR

FTA PRODUCED

98 FIELD-BASED FLR REPORTS IN 48 COUNTRIES

FTA CONDUCTED

60 COUNTRY SURVEYS IN 42 COUNTRIES



GATHERED FIELD BASED DATA

COUNTRY DATA USED FOR SYNTHESIS/ SURVEYS

FIELD BASED & SYNTHESIS/SURVEY

FTA PRODUCED

21 FLR SYNTHESIS REPORTS IN 14 LATIN AMERICAN COUNTRIES

FTA HAS PRODUCED RELEVANT FLR REPORTS IN

69 COUNTRIES

FTA HAS PRODUCED

13 GLOBAL FLR SYNTHESIS REPORTS

7. Contributions to national and international dialogues

FTA has also contributed substantially to enriching international dialogues and fora, and to key global assessments of FLR in its multiple dimensions. FTA is a member of the Global Partnership on Forest Landscape Restoration, and FTA scientists were present at the launch of the Bonn Challenge in 2011. FTA partners are active members of the New York Declaration on Forests Assessment Group (NYDF Assessment Partners 2019) and form part of the Steering Committee of the upcoming edition of the Global Land Outlook.[19] FTA members are also technical partners of the Latin American 20x20 Initiative, technical advisor to the African restoration initiative AFR100 (CIFOR 2019) and the FAO Monitoring Task Force in support of the UN Decade on Ecosystem Restoration,[20] and have taken part in international, high-level scientific workshops on FLR, such as the Latsis Symposium Series (Pallares 2018) and intergovernmental workshops of the Convention on Biological Diversity on ecosystem restoration in the context of the post-2020 global biodiversity framework.[21] Relevant FTA work has been cited as essential reference in the IPBES Assessment Report on Land Degradation and Restoration (Montanarella et al. 2018), the first edition of the Global Land Outlook (UNCCD 2017), the Global Biodiversity Outlook 5 (Secretariat of the Convention on Biological Diversity 2020) and textbooks of international relevance. [22]

[19] https://knowledge.unccd.int/glo/glo-2nd-edition-coming-2021
[20] http://www.fao.org/redd/news/detail/en/c/1293753/
[21] https://www.cbd.int/doc/c/cdb5/7d87/176326ade3fb6fea7f96ca13/post2020-ws-2019-11-05-en.pdf
[22] For an example, see https://islandpress.org/books/primer-ecological-restoration

FTA scientists have also provided inputs to the development of the strategy document for the UN Decade on Ecosystem Restoration (UNEP 2020). In addition, many FTA scientists have contributed as panelists or presenters at global conferences such as the Kew Conference on Reforestation for Biodiversity, Carbon Capture and Livelihoods,[23] and the Global Landscapes Forum on tree planting (Box 1).

Box 1. The right tree for the right place and the right purpose

On 29 September 2020, FTA partners and FTA researchers participated in the on-line meeting "Can tree planting save our planet?" in collaboration with the Global Landscapes Forum. The meeting also included community leaders, investors and policymakers. Close to 5,000 participants from 123 countries tuned in to the forum, which included 27 presentations and reached at least 5 million people via social media. Panelists and participants highlighted inclusion and knowledge-based land restoration as critical next steps. They also said it was important to mobilize more private capital, secure a better supply of high-quality seeds and recognize the full value of trees as a social asset. Other suggestions for future action included overcoming the misconceptions of tree planting as an easy fix for climate change, improving its efficiency through technology and techniques, and including fire prevention and natural regeneration in land restoration efforts. Key messages from the meeting were:

- Tree planters should become tree growers, with a long-term time horizon;
- The right tree requires the right seed. To plant and grow a diverse range of trees means having quality seeds available in the necessary quantities;
- Tree planting is only one tool in the fight against climate change and must be supported by other measures, such as carbon emissions reduction and forest conservation;
- Technology and techniques such as drones, smartphone apps and remote imaging accelerate the planting process and provide essential information on potential sites, growth monitoring and natural regeneration;
- Inclusion of local communities, women and youth is vital in the decision-making process to help ensure the survival of a planted tree.

[23] https://www.kew.org/science/engage/get-involved/conferences/reforestation-biodiversity-carbon-capture-livelihoods

8. Moving forward

The varied contributions from FTA on the topic of forest and landscape restoration highlighted here are expected to continue to inform the science, policy and practice of FLR and will remain part of FTA's legacy while providing essential ways to move the global restoration agenda forward. That being said, future areas of action and strategic pathways have been proposed by restoration experts (Aronson et al. 2020; Fischer et al. 2020) in the context of the UN Decade on Ecosystem Restoration (UNEP 2020). In general, these recommendations reiterate holism, interdisciplinarity and social inclusiveness as the cornerstones of any restorative intervention; emphasize the inclusion of and respect for traditional ecological knowledge; call for working across productive sectors and moving out of silos; and urge enhanced on-site training and capacity building. Restoration experts are further insisting on enhancing the application of transdisciplinary approaches and expertise in managing and dealing with complexity, and including long-distance, socioecological telecoupling[24] processes. And last but not least, on strengthening the evidence base for improving restoration practice (Cooke et al. 2019). As mentioned, the outputs of FTA included here touched upon many of these issues in one way or the other.

Yet some challenges remain. For example, ten years after the launch of the Bonn Challenge, FLR projects and programs across the globe almost uniformly suffer from insufficient, non-inclusive monitoring and reporting schemes, thus hampering social learning and adapting to change over the

[24] Telecoupling means that human-caused processes in one part of the world can affect other parts of the world, even places far distant from the source.

long term (Ota et al. 2020; Höhl et al. 2020; Schweitzer et al. 2021b; Stanturf and Mansourian 2020). The necessity of investing in a long-term vision from an institutional, technical and socioeconomic dimension needs no further emphasis, as clearly stated in Principle 6 of FLR on adaptive management (Table 1). As became clear at the 2020 FTA Science Conference[25] on the added value of a strong and diverse research-for-development partnership to address complex issues, it is hoped that FTA partners further capitalize on the last 10 years of collaboration in order to improve FLR interventions. As the UN Decade on Ecosystem Restoration is already in full force, there is an urgent need to update and further refine previous efforts at informing the policies and practices that underpin the design of FLR projects and programs. It is hoped that the work of FTA over the last decade further contributes to this end.

[25] https://www.kew.org/science/engage/get-involved/conferences/reforestation-biodiversity-carbon-capture-livelihoods

References

Abera W, Tamene L, Tibebe D, Adimassu Z, Kassa H, Hailu K, Mekonnen K, Desta G, Sommer R and Verchot L. 2019. Characterizing and evaluating the impacts of national land restoration initiatives on ecosystem services in Ethiopia. *Land Degradation and Development 3*1(1):35-52. https://doi.org/10.1002/ldr.3424.

Atkinson R, Thomas E, Cornelius J, Zamora R and Franco Chuaire M. 2018. Fit for purpose seed supply systems for the implementation of landscape restoration under Initiative 20x20: An analysis of national seed systems in Mexico, Guatemala, Costa Rica, Colombia, Peru, Chile and Argentina. Lima, Peru: World Resources Institute, Bioversity International, ICRAF, https://cgspace.cgiar.org/bitstream/handle/10568/93037/Fit-for-purpose_Atkinson__may2018.pdf.

Aronson J, Goodwin N, Orlando L, Eisenberg C and Cross A. 2020. A world of possibilities: six restoration strategies to support the United Nation's Decade on Ecosystem Restoration. *Restoration Ecology* 28 (4): 730-736. https://doi.org/10.1111/rec.13170.

Atmadja S, Eshete A and Boissière M. 2019. Guidelines on sustainable forest management in drylands of Ethiopia. Rome: FAO. https://www.cifor.org/publications/pdf_files/Books/BAtmadja1901.pdf.

Baral H, Guariguata MR and Keenan RJ. 2016. A proposed framework for assessing ecosystem goods and services from planted forests. *Ecosystem Services* 22: 260–268. https://doi.org/10.1016/j.ecoser.2016.10.002.

Basnett BS, Elias M, Ihalainen M and Paez Valencia AM. 2017. Gender matters in Forest Landscape Restoration: A framework for design and evaluation. CIFOR. https://www.cifor.org/library/6685.

Bennett MT, Xie C, Hogarth NJ, Peng D and Putzel L. 2014. China's Conversion of Cropland to Forest Program for household delivery of ecosystem services: how important is a local implementation regime to survival rate outcomes? *Forests* 5 (9): 2345–2376. https://doi.org/10.3390/f5092345.

Besseau P. Graham S and Christophersen T. eds. 2018. *Restoring forests and landscapes: the key to a sustainable future.* Vienna, Austria: Global Partnership on Forest and Landscape Restoration. https://www.forestlandscaperestoration.org/images/gpflr_final%2027aug.pdf.

Boissière M, Beyessa M and Atmadja S. 2019. Guiding Principles for Sustainable Bamboo Forest Management Planning: Benishangul-Gumuz Regional State (BGRS). Rome: FAO. https://www.cifor.org/knowledge/publication/7220.

Bonnesoeur V, Locatelli B, Guariguata MR, Ochoa-Tocachi B, Vanacker V, Mao Z, Stokes A and Mathez-Stiefel S-L. 2019. Impacts of forests and reforestation on hydrological services in the Andes: a systematic review. *Forest Ecology and Management* 433: 569–584. https://doi.org/10.1016/j.foreco.2018.11.033.

Bozzano M, Jalonen R, Thomas E, Boshier D, Gallo L, Cavers S, Bordács S, Smith P and Loo J. eds. 2014. Genetic considerations in ecosystem restoration using native tree species. State of the World's Forest Genetic Resources - Thematic study, FAO and Bioversity International, Rome.

Brancalion PHS, Niamir A, Broadbent E, Crouzeilles R, Barros FSM, Almeyda Zambrano AM, Baccini A, Aronson J, Goetz S, Leighton Reid J, et al. 2019. Global restoration opportunities in tropical rainforest landscapes. *Science Advances* Vol 5 (7): eaav3223.

CGIAR-IEA. 2014. Evaluation of CGIAR Research Program on Forests, Trees, and Agroforestry (FTA). Rome, Italy: Independent Evaluation Arrangement (IEA) of CGIAR.

Chazdon RL, Gutierrez V, Brancalion PHS, Laestadius L and Guariguata MR. 2020a. Co-creating conceptual and working frameworks for implementing forest and landscape restoration based on core principles. *Forests* 11(6): 706. https://doi.org/10.3390/f11060706.

Chazdon RL, Lindenmayer D, Guariguata MR, Crouzeilles R, Rey Benayas J and Lazos-Chavero E. 2020b. Fostering natural forest regeneration on former agricultural land through economic and policy interventions. *Environmental Research Letters* 15 (4). https://doi.org/10.1088/1748-9326/ab79e6.

CIFOR. 2019. CIFOR named technical advisor to African restoration initiative AFR100. Corporate News. Bogor, Indonesia: CIFOR. https://www.cifor.org/corporate-news/cifor-named-technical-advisor-to-african-restoration-initiative-afr100/.

CIFOR-ICRAF. 2021. CIFOR-ICRAF strategy 2020–2030. Bogor, Indonesia: Center for International Forestry Research (CIFOR) and Nairobi, Kenya: World Agroforestry (ICRAF). https://www.cifor-icraf.org/about/strategy.

Cooke SJ, Bennett JR and Jones HP. 2019. We have a long way to go if we want to realize the promise of the "Decade on Ecosystem Restoration". *Conservation Science and Practice* 1(12):e129. https://doi.org/10.1111/csp2.129.

Coppus R, Romijn JE, Méndez-Toribio M, Murcia C, Thomas E, Guariguata MR, Herold M and Verchot L. 2019. What is out there? A typology of land restoration projects in Latin America and the Caribbean. *Environmental Research Communications* 1(4). https://doi.org/10.1088/2515-7620/ab2102.

Creed IF and van Noordwijk M. eds. 2018. Forest and Water on a Changing Planet: Vulnerability, Adaptation and Governance Opportunities. A Global Assessment Report. IUFRO World Series. https://www.iufro.org/fileadmin/material/publications/iufro-series/ws38/ws38.pdf.

Cronkleton P, Artati Y, Baral H, Paudyal K, Banjane MR, Liu JL, Tu TY, Putzel L, Birhane E and Kassa H. 2017. How do property rights reforms provide incentives for forest landscape restoration? Comparing evidence from Nepal, China and Ethiopia. *International Forestry Review* 19(4): 8–23. https://www.cifor.org/publications/pdf_files/articles/ACronkleton1701.pdf.

Crossland M and Paez-Valencia AM. 2020. *Impact of On-Farm Land Restoration Practices on the Time and Agency of Women in The Drylands of Eastern Kenya.* Nairobi: World Agroforestry Centre (ICRAF). http://www.worldagroforestry.org/output/impact-farm-land-restoration-practices-time-and-agency-women-drylands-eastern-kenya.

Crossland M, Winowiecki L, Pagella T, Hadgu K and Sinclair F. 2018. Implications of Variation in Local Perception of Degradation and Restoration Processes for Implementing Land Degradation Neutrality. *Environmental Development* 28: 42–54. https://doi.org/10.1016/j.envdev.2018.09.005.

Crouzeilles R, Maurenza D, Prieto PV, Barros FSP, Jakovac C, Ferreira MS, Chazdon RL, Lindenmayer DB, Brancalion PHS, Ceccon E, Adams C, Lazos-Chavero E, Monteiro L, Junqueira AB, Strassburg BBN and Guariguata MR. 2020. Direct and indirect socio-ecological drivers of variation in biodiversity recovery in naturally regenerating tropical and subtropical forests. *Conservation Letters* 14(2)e12768. https://doi.org/10.1111/conl.12768.

Dinerstein E, Olson D, Joshi A, Vynne C, Burgess ND, Wikramanayake E, Hahn N, Palminteri S, Hedao P, Noss R, et al., 2017. An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm. *BioScience* 67 (6): 534–545. https://doi.org/10.1093/biosci/bix014.

Duguma L, Kamwilu E, Minang PA, Nzyoka J and Muthee K. 2020. Ecosystem-Based Approaches to Bioenergy and the Need for Regenerative Supply Options for Africa. *Sustainability* 12(20): 8588. https://doi.org/10.3390/su12208588.

Durai J and Long TT. 2019. *Manual for Sustainable Management of Clumping Bamboo Forest*. INBAR Technical Report No. 41. Beijing: International Bamboo and Rattan Organisation. https://www.inbar.int/wp-content/uploads/2020/05/1578457574.pdf.

Ellison D, Morris CE, Locatelli B, Sheil D, Cohen J, Murdiyarso D, Gutierrez V, van Noordwijk M, Creed IF, Pokorny J, et al. 2017. Trees, forests and water: Cool insights for a hot world. *Global Environmental Change* 43: 51–61. https://doi.org/10.1016/j.gloenvcha.2017.01.002.

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

Evans K, Guariguata MR and Brancalion PHS. 2018. Participatory monitoring to connect local and global priorities for forest restoration. *Conservation Biology* 32(3): 525–534 https://doi.org/10.1111/cobi.13110.

FAO (Food and Agriculture Organization) and INBAR (International Bamboo and Rattan Organisation). 2018. Bamboo for land restoration. INBAR Policy Synthesis Report 4. INBAR: Beijing, China. https://www.inbar.int/wp-content/uploads/2020/05/1528867712.pdf.

Fischer J, Riechers M, Loos J, Martin-Lopez B and Temperton VM. 2020. Making the UN Decade on Ecosystem Restoration a Social-Ecological Endeavour. *Trends in Ecology and Evolution* 36(1): 20–28. https://doi.org/10.1016/j.tree.2020.08.018.

Freeman OE, Duguma LA and Minang PA. 2015. Operationalizing the integrated landscape approach in practice. *Ecology and Society* 20 (1): 24. http://doi.org/10.5751/ES-07175-200124.

Fremout T, Thomas E, Gaisberger H, van Meerbeek K, Muenchow J, Briers S, Gutierrez-Miranda C, Marcelo-Peña JL, Kindt R, Atkinson R, et al. 2020. Mapping tree species vulnerability to multiple threats as a guide to conservation and restoration of tropical dry forests. *Global Change Biology* 26: 3552–3568. https://doi.org/10.1111/gcb.15028.

Gann GD, McDonald T, Walder B, Aronson J, Nelson CR, Nelson J, Eisenberg C, Hallet J, Guariguata MR, Liu J, et al. 2019. International standards and principles for the practice of ecological restoration. *Restoration Ecology* 27 (S1): S1-S46. https://doi.org/10.1111/rec.13035.

Gitz V, Place F, Koziell I, Pingault N, van Noordwijk M, Meybeck A and Minang P. 2020a. *A joint stocktaking of CGIAR work on forest and landscape restoration.* Working Paper 4. Bogor, Indonesia: The CGIAR Research Program on Forests, Trees and Agroforestry (FTA).

Gitz V, Meybeck A, Garavaglia V and Louman B. 2020b. Upscaling restoration: how to unlock finance. *Unasylva* No. 252 (Vol. 71): 109–118. https://doi.org/10.4060/cb1600en.

Guariguata MR and Evans K. 2020. A diagnostic for collaborative monitoring in forest landscape restoration. *Restoration Ecology* 28: 742–749. https://doi.org/10.1111/rec.13076.

Guariguata MR, Arce J, Ammour T and Capella J. 2017. *Las plantaciones forestales en Perú: Reflexiones, estatus actual y perspectivas a future.* Bogor, Indonesia: CIFOR. https://www.cifor.org/knowledge/publication/6461.

Guariguata MR, Chazdon, RL, Brancalion PHS and Lindenmayer D. 2019. Forests: when natural regeneration is unrealistic. *Nature* 570: 164. https://doi.org/10.1038/d41586-019-01776-5.

Harrison RD, Swinfield T, Ayat A, Dewi S, Silalahi M and Herianshah I. 2020. Restoration concessions: A second lease of life for beleaguered tropical forests. *Frontiers in Ecology and Environment* Vol. 18(10): 567–575. https://doi.org/10.1002/fee.2265.

Harvey CA and Guariguata MR. 2020. Raising the profile of woodfuels in the forest landscape restoration agenda. *Conservation Science and Practice* 3(2)e342. https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/csp2.342.

Höhl M, Ahimbisibwe V, Stanturf JA, Elsasser P, Kleine M and Bolte A. 2020. Forest Landscape Restoration—What generates failure and success? *Forests* 11 (9): 938. https://doi.org/10.3390/f11090938.

Hughes K, Oduol J, Kegode H, Ouattara I, Vagen T, Winowiecki LA, Bourne M, Neely C, Ademonla DA, Carsan S, et al. 2020. Regreening Africa Consolidated Baseline Survey Report: Nairobi, Kenya: World Agroforestry. http://apps.worldagroforestry.org/downloads/Publications/PDFS/RP20046.pdf.

ICRAF. 2020. Nested Communities of Practice: Co-learning and sharing lessons learned to scale farmer centered restoration options in East Africa and the Sahel. Nairobi: World Agroforestry Centre (ICRAF). http://www.worldagroforestry.org/output/nested-communities-practice.

Ilstedt U, Tobella AB, Bazié HR, Bayala J, Verbeeten E, Nyberg G, Sanou J, Benegas L, Murdiyarso D, Laudon H, et al. 2016. Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics. *Scientific Reports* 6:21930. https://doi.org/10.1038/srep21930.

IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services). 2018. *IPBES assessment report on land degradation and restoration.* Secretariat of the IPBES, Bonn, Germany. https://ipbes.net/assessment-reports/ldr.

ITTO (International Tropical Timber Organization). 2020. *Guidelines for forest landscape restoration in the tropics.* Policy Development Series No. 24. Yokohama, Japan: ITTO. https://www.itto.int/direct/topics/topics_pdf_download/topics_id=6511&no=1&disp=inline.

Jalonen R, Valette M, Boshier D, Duminil J and Thomas E. 2018. Forest and landscape restoration severely constrained by a lack of attention to the quantity and quality of tree seed: insights from a global survey. *Conservation Letters* 11: e12424. https://doi.org/10.1111/conl.12424.

Jamnadass RH, McMullin S, Iiyama M, Dawson IK, Powell B, Termote C, Ickowitz A, Kehlenbeck K, Vinceti B, Van Vliet N, et al. 2015. Understanding the Roles of Forests and Tree–based Systems in Food Provision. In Vira B, Wildburger C and Mansourian S (eds.). *Forests, Trees and Landscapes for Food Security and Nutrition: A Global Assessment Report*, pp. 25–50. IUFRO World Series no. 33. International Union of Forest Research Organizations (IUFRO). https://www.cifor.org/knowledge/publication/5594.

Jansen M, Guariguata MR, Raneri JE, Ickowitz A, Chiriboga-Arroyo F, Quaedvlieg J and Kettle CJ. 2020. Food for thought: the underutilized potential of tropical tree-sourced foods for 21st century sustainable food systems. *People and Nature.* https://doi.org/10.1002/pan3.10159.

Kassa H, Birhane E, Bekele M, Lemenih M, Cronkleton P, Putzel L and Baral H. 2017. Shared strengths and limitations of participatory forest management and area exclosure: two major state led landscape rehabilitation mechanisms in Ethiopia. *International Forestry Review* 19(4): 51–61. https://doi.org/10.1505/146554817822330560.

Kindt R, van Breugel P, Orwa C, Lillesø J-PB, Jamnadass R and Graudal L. 2015. *Useful tree species for Eastern Africa: a species selection tool based on the VECEA map.* Version 2.0. World Agroforestry Centre (ICRAF) and Forest & Landscape Denmark. http://vegetationmap4africa.org.

Kiptot E, Franzel S and Degrande A. 2014. Gender, agroforestry and food security in Africa. *Current Opinion in Environmental Sustainability* 6: 104–109. https://doi.org/10.1016/j.cosust.2013.10.019.

Lillesø J-PB, Dawson IK, Graudal L and Jamnadass R. 2021. *Quality seed for tree planting: Supporting more effective agroforestry and forest landscape restoration by learning from crop integrated seed system development.* ICRAF Policy Brief 54. World Agroforestry Centre (ICRAF), Nairobi, Kenya. http://apps.worldagroforestry.org/downloads/Publications/PDFS/PB21003.pdf.

Lillesø J-PB, Harwood C, Derero A, Graudal L, Roshetko JM, Kindt R, Moestrup S, Omondi W, Holtne N, Mbora A, et al. 2018. Why Institutional Environments for Agroforestry Seed Systems Matter. *Development Policy Review* 36(51). http://onlinelibrary.wiley.com/doi/10.1111/dpr.12233/full.

Lillesø J-PB, van Breugel P, Kindt R, Bingham M, Demissew S, Dudley C, Friis I, Gachathi F, Kalema J, Mbago F, et al. 2011. *Potential Natural Vegetation of Eastern Africa (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia)*. Volume 1: The Atlas. Forest & Landscape, University of Copenhagen, 2011. 155 s. Forest and Landscape Working Papers 61/2011. https://ign.ku.dk/english/employees/forest-nature-biomass/?pure=en%2Fpublications%2Fpotential-natural-vegetation-of-eastern-africa-ethiopia-kenya-malawi-rwanda-tanzania-uganda-and-zambia-volume-1(48040898-e729-4910-ab90-835e890e64ed)%2Fexport.html.

Loo J, Souvannavong O and Dawson I. eds. 2014. Global Forest Genetic Resources: Taking Stock. F*orest Ecology and Management* 333: 1–98. https://www.sciencedirect.com/journal/forest-ecology-and-management/vol/333/suppl/C.

Liyama M, Neufeldt H, Dobie P, Njenga M, Ndegwa G and Jamnadass R. 2014. The potential of agroforestry in the provision of sustainable woodfuel in sub-Saharan Africa. *Current Opinion in Environmental Sustainability* 6: 138–147. https://doi.org/10.1016/j.cosust.2013.12.003.

Locatelli B, Catterall CP, Imbach P, Kumar C, Lasco R, Marín-Spiotta E, Mercer B, Powers JS, Schwartz N and Uriarte M. 2015. Tropical reforestation and climate change: Beyond carbon. *Restoration Ecology* 23(4): 337–343. https://doi.org/10.1111/rec.12209.

Locatelli B, Pramova E, Di Gregorio M, Brockhaus M, Chávez DA, Tubbeh R, Sotés J and Perla J. 2020. Climate change policy networks: connecting adaptation and mitigation in multiplex networks in Peru. *Climate Policy* 20(3): 354-372 https://doi.org/10.1080/14693062.2020.1730153.

Lohbeck M, Albers P, Boels L, Bongers F, Morel S, Sinclair F, Bertin T, Vågen T-G, Winowiecki L and Smith Dumont, E. 2020. Drivers of farmer-managed natural regeneration in the Sahel: Lessons for restoration. *Scientific Reports* 10e15038. https://www.nature.com/articles/s41598-020-70746-z.

McLain R, Lawry S and Yazew B. 2019. *Fostering tenure security for forest landscape restoration in Ethiopia: Creating enabling conditions for the 2018 Forest Proclamation.* CIFOR Info Brief No. 267. Bogor, Indonesia: CIFOR.

McLain R, Lawry S, Guariguata MR 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.

Meli P, Schweizer D, Brancalion PHS, Murcia C and Guariguata MR. 2019. Multi-dimensional training among Latin America's restoration professionals. *Restoration Ecology* 27: 477–484. https://doi.org/10.1111/rec.12933.

Méndez-Toribio M, Martínez-Garza C, Ceccon E and Guariguata MR. 2018. La restauración de ecosistemas terrestres en México: Estado actual, necesidades y oportunidades. Documentos Ocasionales 185. Bogor, Indonesia: CIFOR. https://www.cifor.org/publications/pdf_files/OccPapers/OP-185.pdf.

Méndez-Toribio M, Martínez-Garza C, Ceccon E and Guariguata MR. 2017. Planes actuales de restauración ecológica en Latinoamérica: avances y omisiones. *Revista de Ciencias Ambientales* 51(2): 1–30.

Mendum R and Njenga M. 2018. Integrating wood fuels into agriculture and food security agendas and research in sub-Saharan Africa. *Facets* 3 (1): 1–11. https://doi.org/10.1139/facets-2017-0032.

Meybeck A, Gitz V, Wolf J and Wong T. 2020. Addressing forestry and agroforestry in National Adaptation Plans – Supplementary guidelines. Bogor/Rome: FAO and FTA. http://www.fao.org/documents/card/en/c/cb1203en.

Meybeck A, Rose S and Gitz V. 2019. Climate change vulnerability assessment of forests and forest-dependent people – A framework methodology. FAO Forestry Paper No. 183. Rome: FAO.

Minang PA, van Noordwijk M, Freeman OE, Mbow C, de Leeuw J and Catacutan D. eds. 2015. *Climate-Smart Landscapes: Multifunctionality in Practice.* Nairobi: World Agroforestry (ICRAF).

Mollins J. 2020. *Kenyan farmers adopt new agroforestry strategies through research in development program*. Forests News. Bogor, Indonesia: CIFOR. https://forestsnews.cifor.org/65934/kenyan-farmers-adopt-new-agroforestry-strategies-through-research-and-development-program-2?fnl=en.

Montanarella L, Scholes R and Brainich A. eds. 2018. *The IPBES assessment report on land degradation and restoration.* Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. https://doi.org/10.5281/zenodo.3237392.

Murcia C and Guariguata MR. 2014. La restauración ecológica en Colombia: Tendencias, necesidades y oportunidades. Bogor, Indonesia: CIFOR. https://doi.org/10.17528/cifor/004519.

Mwangi E, Meinzen-Dick R and Sun Y. 2011. Gender and sustainable forest management in East Africa and Latin America. *Ecology and Society* 16 (1)17. http://www.cifor.org/library/3343/genderand-sustainable-forest-management-in-east-africa-and-latin-america.

NYDF Assessment Partners. 2019. Protecting and Restoring Forests: A Story of Large Commitments Yet Limited Progress. New York Declaration on Forests Five-Year Assessment Report. Climate Focus (coordinator and editor). https://forestdeclaration.org/images/uploads/resource/2019NYDFReport.pdf

Ota L, Chazdon RL, Herbohn J, Gregorio N, Mukul SA and Wilson SJ. 2020. Achieving quality forest and landscape restoration in the tropics. *Forests* 11 (8): 820. https://doi.org/10.3390/f11080820.

Pallares G. 2018. *How to take forest landscape restoration to the next level: Latsis Symposium maps out strategies to scale up FLR globally.* Forests News. Bogor, Indonesia: CIFOR. https://forestsnews.cifor.org/56768/how-to-take-forest-landscape-restoration-to-the-next-level?fnl=en.

Paudyal K, Adhikari S, Sharma S, Samsudin YB, Paudyal BR, Bhandari A, Birhane E, Darcha G, Trinh TL and Baral H. 2019. *Framework for assessing ecosystem services from bamboo forests: Lessons from Asia and Africa.* Working Paper 255. Bogor, Indonesia: CIFOR. https://www.inbar.int/wp-content/uploads/2020/05/1573091377.pdf.

Paudyal K, Samsudin Y, Baral H, Okarda B, Phuong V, Paudel S and Keenan R. 2020. Spatial Assessment of Ecosystem Services from Planted Forests in Central Vietnam. *Forests* 11: 822. https://doi.org/10.3390/f11080822.

Piponiot C, Sist P, Mazzei L, Peña-Claros M, Putz FE, Rutishauser E, Shenkin A, Ascarrunz N, de Azevedo CP, Baraloto C, et al. 2016. Carbon recovery dynamics following disturbance by selective logging in Amazonian forests. *eLife* 2016; 5:e21394. https://doi.org/10.7554/eLife.21394.

Pramova E, Locatelli B, Djoudi H, Lavorel S, Colloff MJ and Martius C. 2019. *Adapting land restoration to a changing climate: Embracing the knowns and unknowns*. CIFOR Info Brief No 249. https://doi.org/10.17528/cifor/007261.

Puspitaloka D, Kim Y-S, Purnomo H and Fulé PZ. 2019. Defining ecological restoration of peatlands in Central Kalimantan, Indonesia. *Restoration Ecology* 28(2): 435–446. https://doi.org/10.1111/rec.13097.

Rahman SA, Baral H, Sharma R, Samsudin Y, Meyer M, Lo M, Artati Y, Simamora T, Andini S, Leksono B, et al. 2019. Integrating bioenergy and food production on degraded landscapes in Indonesia for improved socioeconomic and environmental outcomes. *Food Energy Secur.* 8:e165. https://doi.org/10.1002/fes3.165.

Reed J, Ickowitz A, Chervier C, Djoudi H, Moombe K, Ros-Tonen M, Yanou M, Yuliani L and Sunderland T. 2020. Integrated landscape approaches in the tropics: A brief stock-take. *Land Use Policy* Vol. 99. https://www.cifor.org/publications/pdf_files/articles/AReed2001.pdf.

Reed J, Van Vianen J, Deakin EL, Barlow J and Sunderland T. 2016. Integrated landscape approaches to managing social and environmental issues in the tropics: learning from the past to guide the future. *Global Change Biology* 22(7): 2540–2554. https://doi.org/10.1111/gcb.13284.

Robiglio V and Reyes M. 2016. Restoration through formalization? Assessing the potential of Peru's Agroforestry Concessions scheme to contribute to restoration in agricultural frontiers in the Amazon region. *World Development Perspectives* 3: 42–46. https://doi.org/10.1016/j.wdp.2016.11.013.

Roshetko JM, Dawson IK, Urquiola J, Lasco RD, Leimona B, Weber JC, Bozzano M, Lillesø J-PB, Graudal L and Jamnadass R. 2017. To what extent are genetic resources considered in environmental service provision? A case study based on trees, carbon sequestration and the Clean Development Mechanism. *Climate and Development* 10(8): 755–768. https://doi.org/10.1080/17565529.2017.1334620.

Rutishauser E, Hérault B, Baraloto C, Blanc L, Descroix L, Doff Sotta E, Ferreira J, Kanashiro M, Mazzei L, d'Oliveira MVN, et al. 2015. Rapid tree carbon stock recovery in managed Amazonian forests. *Current Biology* 25 (18): R787–R788. https://doi.org/10.1016/j.cub.2015.07.034.

Sayer J, Sunderland T, Ghazoul J, Pfund J-L, Sheil D, Meijaard E, Venter M, Boedhihartono AK, Day M and Garcia C. 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences.*110: 8349–8356.

Schweizer D, Meli P, Brancalion PHS and Guariguata MR. 2021a. Implementing forest landscape restoration in Latin America: stakeholder perceptions on legal frameworks. *Land Use Policy* Vol. 104 e104244. https://doi.org/10.1016/j.landusepol.2019.104244.

Schweizer D, van Kuijk M and Ghazoul J. 2021b. Perceptions from non-governmental actors on forest and landscape restoration, challenges and strategies for successful implementation across Asia, Africa and Latin America. *Journal of Environmental Management.* 286:112251. http://doi.org/10.1016/j.jenvman.2021.112251.

Sears RR, Cronkleton P, Villanueva FP, Ruiz MM and del Arco MPO. 2018. Farm-forestry in the Peruvian Amazon and the feasibility of its regulation through forest policy reform. *Forest Policy and Economics* 87: 49–58. https://doi.org/10.1016/j.forpol.2017.11.004.

Secretariat of the Convention on Biological Diversity. 2020. *Global Biodiversity Outlook* 5. Montreal: Secretariat of the Convention on Biological Diversity. https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf.

Sheil D, Bargués-Tobella A, Ilstedt U, Ibisch PL, Makarieva A, Mcalpine C, Morris CE, Murdiyarso D, Nobre AD, Poveda G, et al. 2019. Forest restoration: Transformative trees. *Science* Vol. 366, Issue 6463: 316–317. https://doi.org/10.1126/science.aay7309.

Sola P, Schure J, Eba'a Atyi R, Gumbo D, Okeyo I and Awono A. 2019. Woodfuel policies and practices in selected countries in Sub-Saharan Africa—A critical review. *Bois et Forêts des Tropiques* 340: 5–19. https://doi.org/10.19182/bft2019.340.a31690.

Stanturf JA, Kant P, Lillesø J-PB, Mansourian S, Kleine M, Madsen P, Graudal L. 2015. *Forest Landscape Restoration as a Key Component of Climate Change Mitigation and Adaptation.* IUFRO World Series No. 34. Vienna: International Union of Forest Research Organizations. https://core.ac.uk/download/pdf/269268107.pdf.

Stanturf JA and Mansourian S. 2020. Forest landscape restoration: state of play. *Royal Society Open Science* 7: 201218. https://doi.org/10.1098/rsos.201218.

Thomas E, Alcazar C, Gonzalo Moscoso L, Osorio LF, Salgado B, Gonzalez M, Parra M, Bozzano M, Loo J, Jalonen R and Ramirez W. 2017. *The importance of species selection and seed sourcing in forest restoration for enhancing adaptive potential to climate change: Colombian tropical dry forest as a model.* CBD Technical Series 89:122–134.

UNCCD (United Nations Convention to Combat Desertification). 2017. *The Global Land Outlook.* First edition. Bonn, Germany: UNCCD. https://knowledge.unccd.int/sites/default/files/2018-06/GLO%20English_Full_Report_rev1.pdf.

UNEP (United Nations Environment Programme). 2020. *The United Nations Decade on Ecosystem Restoration: Strategy.* New York: UNEP. https://wedocs.unep.org/bitstream/handle/20.500.11822/31813/ERDStrat.pdf?sequence=1&isAllowed=y.

Vågen T-G and Winowiecki L. 2019. Predicting the Spatial Distribution and Severity of Soil Erosion in the Global Tropics using Satellite Remote Sensing. *Remote Sensing.* 11, 1800. https://www.mdpi.com/2072-4292/11/15/1800.

Vågen T-G and Winowiecki L. 2013. Mapping of soil organic carbon stocks for spatially explicit assessments of climate change mitigation potential. *Environmental Research Letters* 8(1):015011. http://dx.doi.org/10.1088/1748-9326/8/1/015011.

Vågen T-G, Winowiecki LA, Abegaz A and Hadgu KM. 2013. Landsat-based approaches for mapping of land degradation prevalence and soil functional properties in Ethiopia. *Remote Sensing of Environment* 134: 266–275. http://dx.doi.org/10.1016/j.rse.2013.03.006.

Vågen T-G, Winowiecki, LA, Tondoh JE, Desta LT, and Gumbricht T. 2016. Mapping of soil properties and land degradation risk in Africa using MODIS reflectance. *Geoderma* 263:216–225. http://dx.doi.org/10.1016/j.geoderma.2015.06.023.

Valette M, Vinceti B, Gregorio N, Bailey A, Thomas E and Jalonen R. 2020. Beyond fixes that fail: identifying sustainable improvements to tree seed supply and farmer participation in forest and landscape restoration. *Ecology and Society* 25(4):30. https://doi.org/10.5751/ES-12032-250430.

van Noordwijk M, Gitz V, Minang PA, Dewi S, Leimona B, Duguma L, Pingault N and Meybeck A. 2020. People-Centric Nature-Based Land Restoration through Agroforestry: A Typology. *Land* 9 (8), 251. https://doi.org/10.3390/land9080251.

van Noordwijk M, Lusiana B, Leimona B, Dewi S and Wulandari D. eds. 2013. *Negotiation-support toolkit for learning landscapes.* Bogor, Indonesia: World Agroforestry Centre (ICRAF), Southeast Asia Regional Program.

Wainaina P, Gituku E and Minang P. 2020. An exploratory study of cost-benefit analysis of landscape restoration. Working Paper number 306. Nairobi, Kenya: World Agroforestry Centre (ICRAF). https://doi.org/10.5716/WP20014.pdf.

Watson C. 2020. *Amid multiple global crises, global forestry and agroforestry centres "reset" with engagement landscapes.* Bogor, Indonesia: CIFOR. https://www.cifor.org/corporate-news/amid-multiple-global-crises-global-forestry-and-agroforestry-centres-reset-with-engagement-landscapes.

Winowiecki LA, Vågen T-G, Kinnaird MF and O'Brien TG. 2018. Application of systematic monitoring and mapping techniques: Assessing land restoration potential in semi-arid lands of Kenya. *Geoderma* 327:107–118. https://www.sciencedirect.com/science/article/pii/S001670611830510X.

The FTA Highlights series

1. Ten Years of Forest, Trees and Agroforestry Research in Partnerships for Sustainable Development: Introducing FTA highlights
2. Tree Seed and Seedling Systems for Resilience and Productivity
3. Conservation of Tree Biodiversity and Sustainable Forest Management
4. **Forest and Landscape Restoration**
5. Food Security and Nutrition
6. Wild Meat
7. Trees on Farms to Improve Livelihoods and the Environment
8. Biomass, Bioenergy and Biomaterials
9. Improving Rural Livelihoods through Supporting Local Innovation at Scale
10. Sustainable Value Chains and Finance
11. REDD+: Combating Climate Change with Forest Science
12. Adaptation to Climate Change with Forests, Trees and Agroforestry
13. Multi-Functional Landscapes for Sustainable Development
14. Governing Forests, Trees and Agroforestry for Delivering on the SDGs
15. Advancing Gender Equality and Social Inclusion
16. Capacity Development
17. Monitoring, Evaluation, Learning and Impact Assessment
18. The Way Forward

This list represents the order of the volumes in the series and not the time sequence of publication.

FTA HIGHLIGHTS OF A DECADE
2011–2021

Forest and Landscape Restoration

Over the last decade, the CGIAR Program on Forests, Trees and Agroforestry (FTA) has undertaken innovative basic and applied research across different scientific disciplines on the multiple dimensions of FLR for improving policy and practice and facilitating the uptake of new knowledge, tools and approaches — both from the top down and the bottom up. This publication presents key FTA outputs on forest and landscape restoration from 2011 to 2021.

DOI: 10.17528/cifor/008214

This is No.4 of the FTA Highlights of a Decade series. Published volumes are indicated below. Other volumes forthcoming.

1 2 3 4 5 6

7 8 9 10 11 12

13 14 15 16 17 18

CGIAR
RESEARCH PROGRAM ON
Forests, Trees and Agroforestry