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A joint stocktaking of CGIAR work on forest and landscape restoration

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A joint stocktaking of CGIAR work on forest and landscape restoration

The CGIAR Research Program on Forests, Trees and Agroforestry (FTA)

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Acknowledgments

This report is part of the collaboration between the three Common Research Programs (CRPs) of the CGIAR Forests, Trees and Agroforestry (FTA), Policies, Institutions and Markets (PIM) and Water, Land and Ecosystems (WLE) under the leadership of Vincent Gitz, Frank Place and Izabella Koziell. The report was prepared by Nathanaël Pingault, Meine van Noordwijk, Alexandre Meybeck, Peter Minang and Vincent Gitz.

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Note: CIAT = International Center for Tropical Agriculture; CIFOR = Center for International Forestry Research; CIMMYT = International Maize and Wheat Improvement Center; CIRAD = Research for Development (CIRAD); ICRAF = World Agroforestry; ICRISAT = International Crops Research Institute for the Semi-Arid Tropics; IFAD = International Fund for Agricultural Development; IFPRI = International Food Policy Research Institute; ILRI = International Livestock Research Institute; IWMI = International Water Management Institute.

1 Introduction

Forest and landscape restoration (FLR) are gaining increased traction on the political agenda. Over the last decade, the number and importance of pledges and commitments on restoration have increased significantly at national, regional and global levels. These include the

- Bonn Challenge (2011)[1]
- New York Declaration on Forests (2014)[2]
- Global Partnership on Forest and Landscape Restoration (GPFLR)[3]
- Land Degradation Neutrality (LDN) Target Setting Programme of the UN Convention to Combat Desertification (UNCCD)[4]
- Great Green Wall Initiative[5]
- African Forest Landscape Restoration Initiative (AFR100)[6]
- Initiative 20x20 in Latin America and the Caribbean[7]
- Asia-Pacific Regional Strategy and Action Plan on Forest and Landscape Restoration to 2030 (APFLR).[8]

On 1 March 2019, the UN General Assembly declared 2021-2030 the UN Decade on Ecosystem Restoration (A/RES/73/284).[9] This Decade could make a huge contribution to address food security, job creation and climate change simultaneously. The UN Environment Programme (UNEP) considers that restoring 350 million hectares (ha) of degraded land by 2030, as committed in the New York Declaration on Forests, could generate USD 9 trillion in various ecosystem services and remove about 13–26 gigatons of greenhouse gases from the atmosphere.[10]

However, despite the high level of political engagement, despite the number of institutions (either public, private or civil society) involved from local to global levels, and beyond some success stories, restoration is not happening at scale. Research is urgently needed to design and develop successful FLR approaches to be implemented at scale in the coming years.

International research institutions, including the CGIAR and its centers, in collaboration with national research systems and local partners on the ground, will play a critical role. This will range from generating knowledge to supporting changes on the ground as part of a "knowledge to action" chain (**Figure 1**), in order to achieve this global restoration effort.

In particular, the CGIAR and its centers need to: (i) identify the priority knowledge gaps faced by the development community; (ii) elaborate and/or assess different restoration options adapted to different contexts, as well as to the objectives and needs of different stakeholders (land users, farmers, etc.); and (iii) recommend ways and means to overcome current technical and institutional barriers and to scale up successful experiences.

1 http://www.bonnchallenge.org

2 http://forestdeclaration.org

3 http://www.forestlandscaperestoration.org

4 https://www.unccd.int/actions/ldn-target-setting-programme

5 https://www.unccd.int/actions/great-green-wall-initiative

6 http://afr100.org

7 https://initiative20x20.org/

8 http://www.fao.org/3/i8382en/I8382EN.pdf

9 https://undocs.org/en/A/RES/73/284

10 https://www.unenvironment.org/news-and-stories/press-release/new-un-decade-ecosystem-restoration-offers-unparalleled-opportunity

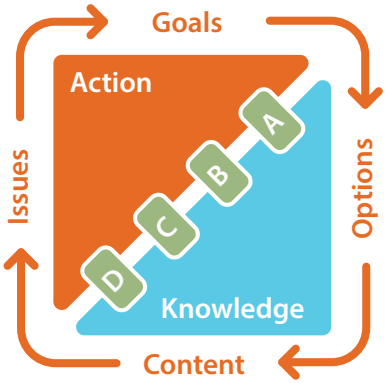

Figure 1. Knowledge to action chains

Note: A: Agenda setting; B: Better and shared understanding; C: Commitment to common principles; D: Devolution of detailed implementation.

Source: Adapted from van Noordwijk (2019); van Noordwijk et al. (2019).

In 2018, three CGIAR Research Programs (CRPs) – Forests, Trees and Agroforestry (FTA); Policies, Institutions and Markets (PIM) and Water, Land and Ecosystems (WLE) – decided to work together to address these needs. There are huge opportunities in bringing the three CRPs together to work on land restoration. Each of these CRPs works on different aspects of land restoration. Pooling this evidence in a user-friendly and accessible manner holds great potential for scaling, and for delivering enhanced impact from our CGIAR research.

The three CRPs organized a joint workshop (31 August – 1 September 2018, Nairobi, ICRAF Headquarters) to explore and define future collaboration on land restoration. As a first step, FTA, PIM and WLE took stock of research by the CGIAR centers and CRPs on landscape restoration, including land restoration and forest restoration. A survey was conducted in the 3 CRPs (FTA, PIM, WLE) and circulated to the other CRPs, inviting contributions (templates in Appendix 1). The answers to this survey (see Appendix 2) reflect the broad range of CGIAR's specific contributions to knowledge, methods, planning, modeling, action on the ground, assessment and evaluation.

This document is a preliminary analysis of the survey results. After a first section on scope, material and methods, it analyses the answers received according to three categories of research for/in development interventions or outputs: case studies and projects; tools for development; analyses and conceptual frameworks (see **Section 2.2** for more details). It also discusses some main results across these functional categories.

2 Scope, material and methods

2.1 Scope

Beyond the narrow approach that considers "restoration" as the return to the initial, pristine, undisturbed state of an ecosystem, the **International Union for Conservation of Nature** (IUCN) and other partners have adopted a wider definition for the Bonn Challenge:[11]

"Forest landscape restoration (FLR) is the ongoing process of ***regaining ecological functionality*** *and* ***enhancing human well-being*** *across deforested or degraded forest landscapes. FLR is more than just planting trees – it is restoring a whole landscape to meet present and future needs and to offer multiple benefits and land uses over time."*

The IUCN and its partners have identified the following guiding principles of FLR: (i) focus on landscapes; (ii) maintain and enhance natural ecosystems within landscapes; (iii) engage stakeholders and support participatory governance; (iv) tailor to the local context using a variety of approaches; (v) restore multiple functions for multiple benefits; and (vi) manage adaptively for long-term resilience.

Building on this IUCN definition, and following the discussions during the Nairobi joint workshop (see **Box 1**), the three CRPs considered a broader scope of land restoration, encompassing any kind of forest and agricultural landscapes all along the "forest transition curve" illustrated in **Figure 2**.

Box 1. Defining some common terms

The following definitions were agreed during the joint FTA-PIM-WLE workshop on land restoration (Nairobi, 2018):

- **Degradation**: Loss of functionality of e.g. land or forests, usually from a specific human perspective, based on change in land cover with consequences for ecosystem services.
- **Degraded lands**: Lands that have lost functionality beyond what can be recovered by natural processes and existing land-use practices in a defined, policy-relevant time frame.
- **Restoration**: Efforts to halt ongoing and reverse past degradation, by aiming for increased functionality (not necessarily recovering past system states).

Source: Adapted from FTA/PIM/WLE (2018)

Encompassing any kind of ecosystem, this approach to restoration gives central place to the concept of "ecological functions", i.e. the functions that allow ecosystems to generate various regulating, supporting, provisioning and cultural services (MA 2005; see also **Figure 3**), including those generating economic value.

In this document, in line with the definitions highlighted in **Box 1**, restoration is defined as all the "efforts to secure recovery of ecological functions allowing the long-term productive use of land", contributing to halt and reverse past or ongoing degradation.

These "efforts" cover a broad range of restoration interventions — from land-use practices and land-use changes to physical

11 https://www.iucn.org/theme/forests/our-work/forest-landscape-restoration; https://infoflr.org/what-flr; http://www.bonnchallenge.org/content/forest-landscape-restoration

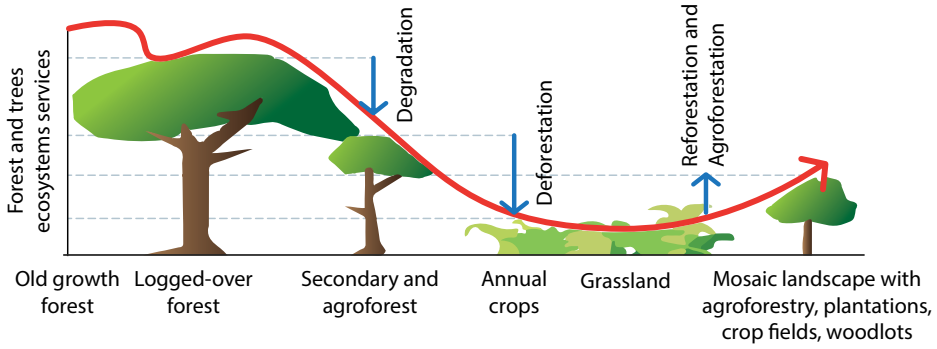

Figure 2. Forest and land-use transition curve

Source: HLPE (2017), adapted from CIFOR (2011).

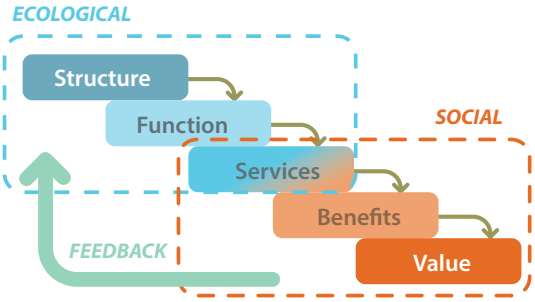

Figure 3. Ecological functions and ecosystem services

Source: Adapted from Namirembe et al. (2017).

infrastructures and institutional changes. As highlighted above, the objective here is to regain ecological functionality and enhance human well-being, not necessarily to go back to the initial ecosystem state or function. Moreover, the final "restored" state of the ecosystem shall be self-sustaining. This means that, in a particular context, given the set of ecological functions to "restore", restoration interventions need to lead to social, economic and ecological benefits lasting in the long-term.

2.2 Material, methods and first results

The initial survey, conducted from 18 July to 15 August 2018, was circulated within FTA, PIM and WLE) and circulated to the other CRPs, inviting their contributions. Researchers were also invited to include information predating the creation of the CRPs. In fact, given the time needed to achieve restoration results, information about old projects was particularly welcome. First results of the survey were presented at the FTA-PIM-WLE workshop organized at World Agroforestry (ICRAF), Nairobi on 31 August – 1 September 2018, as part of a global stocktaking of activities on restoration in the CGIAR.

In all, **77 answers** were received (gathered in **Appendix 2**), testifying to the interest of researchers in this topic. Most answers emanated from the three CRPs: 27 from FTA; 19 from WLE; 8 from PIM; 1 from FTA & PIM; 1 from FTA & WLE; and 1 from PIM & WLE. 20 answers were not explicitly linked to one of these three CRPs: 19 came from ICRAF; 15 from Bioversity; 14 from CIFOR (including 3 in collaboration with CIRAD); 10 from CIAT; 7 from IWMI; 5 from ILRI; 4 from ICRISAT, 1 from CIMMYT; and 1 from IFPRI.

As appropriate, the analysis below refers to specific contributions as numbered in **Appendix 2**.

One answer (#1) describing the reforestation project of Mont Aigoual, Massif Central, in France, while of major interest, has been, at this stage, excluded from the analysis below because this old project (1850-1913) is not yet related to any CGIAR research project and falls out of the CGIAR geographical scope. It will be part of a later review paper. The 76 remaining answers reflect the wide diversity of restoration activities led by the CGIAR all over the world, across the tropics and sub-tropics: 31 answers focused on Africa;

Table 1. Answers by regions and sub-regions

Regions	Number of answers	List of answers
Africa	**31**	
Eastern Africa	15	(#5, #10, #14, #15, #26, #39, #40, #53, #56, #57, #58, #63, #64, #69, #70)
Western Africa	7	(#2, #3, #8, #12, #21, #32, #60)
Others	9	(#27, #33, #47, #54, #59, #61, #62, #73, #76)
Asia	**13**	
South-Eastern Asia	10	(#4, #9, #16, #17, #29, #37, #43, #48, #74, #75)
Southern Asia	3	(#11, #13, #18)
Latin America	**8**	
South America	5	(#20, #24, #30, #31, #42)
Central America	1	(#22)
Others	2	(#23, #41)
Cross-regional or global	**24**	(#6, #7, #19, #25, #28, #34, #35, #36, #38, #44, #45, #46, #49, #50, #51, #52, #55, #65, #66, #67, #68, #71, #72, #77)
Total	**76**	

13 on Asia; 8 on Latin America; and 24 were either cross-regional or global (**Table 1**).

In each region, some countries emerge as places of concentration of projects. **Table 2** shows, for the main countries of concentration, the projects focusing on (or including a component on) these countries.

Initially, this survey aimed to inform the mapping of past and recent restoration activities of the CGIAR. However, out of **76 answers** analysed, only 21 describe past projects. In all, 55 answers describe ongoing projects[12], of which 24 were still at a too early stage (inception, data collection or development phase) to properly assess their impacts, either on the ground and/or in terms of publications. Some answers did not provide enough information to be fully integrated into the analysis at this stage.

Of the answers, 45 focused explicitly on restoration. For 31 answers, the main focus was not restoration but other issues, closely or more indirectly related to restoration. Beyond forest and landscape restoration, other salient topics emerged from the answers. These comprised sustainable land management (18 answers), including 8 that presented tools to monitor and map soil information and 2 focusing more on sustainable water management; genetic diversity and seed supply systems in restoration projects (13 answers); climate change — adaptation and/or mitigation (13 answers); and land tenure security and land governance reform (5 answers).

Most contributions operated at landscape level (30 answers) or across multiple scales (31 answers) — from plot, farm and landscape to national, regional and global levels. This focus may reflect the importance of the landscape level for effective restoration interventions as this level combines an integrated perspective that allows synergies among different ecosystem components and functions with a deep knowledge of, and a fine adaptation to, local conditions.

To facilitate the analysis, the survey distinguished three broad functional categories of contributions. They correspond to the description of three types of research for/in development interventions

12 i.e. projects that were ongoing in August 2018 when the survey was conducted.

Table 2. Answers focusing on or including a component on specific countries

Countries	Number of answers	List of answers
Africa		
Ethiopia	16	(#5, #7, #10, #15, #39, #52, #53, #55, #56, #57, #64, #69, #70, #72, #73, #76)
Kenya	8	(#15, #27, #39, #58, #63, #72, #73, #76)
Tanzania	5	(#14 #26, #39, #40, #72)
Niger	5	(#2, #12, #72, #73, #76)
Burkina Faso	3	(#21, #27, #32)
Senegal	3	(#3, #72, #73)
Asia		
Indonesia	5	(#4, #9, #35, #37, #43)
India	3	(#11, #13, #72)
Vietnam	3	(#43, #74, #75)
Latin America		
Peru	6	(#19, #24, #30, #35, #41, #42)
Colombia	3	(#20, #31, #41)

or outputs, with a dedicated template questionnaire for each of these categories (see **Appendix 1**):

- **Case studies and projects (CSP)**, either pilot projects or up-scaling
- **Tools for development (T4D)**, aimed at facilitating decision making and/or stakeholder negotiations
- **Approaches and conceptual frameworks (ACF)**, including evaluations.

The questions were formulated as open or semi-open questions to collect raw material, allowing further interpretation and exploitation of the answers. An Excel database was constituted for this analysis, gathering and organizing this raw material along the different headings of the questionnaire for each of the three broad functional categories as classified by the respondents.

However, four answers did not use the template questionnaires proposed for this survey. Moreover, in some cases, respondents used a template that was not the one dedicated to the corresponding functional category (see **Appendix 1**). Some also placed a research project in a category that was not considered the most appropriate by the team preparing this analysis. A new categorization is therefore proposed for such cases (15 answers) after internal discussion. As per this new categorization, 39 answers were classified as CSP, 22 as T4D and 12 as ACF. They are presented in more detail in the next sections.

3 Case studies and projects (CSP)

This category gathers 39 answers, either pilot projects or up-scaling, comprising an element of field research. These include experimental plots, trials, local capacity building and implementation, on-the-ground assessments and surveys at different scales.

3.1 Functional sub-categories

The following functional sub-categories of CSP can be distinguished:

3.1.1 Field assessments (12 answers)

This sub-category comprises projects and activities assessing the cost-efficiency of various restoration initiatives (#20); their biophysical or socio-economic impacts/ outcomes/benefits (#4, #19, #56, #58, #69), including their impacts on specific issues such as climate change (#6), water security (#58) or genetic diversity (#21, #42). It also includes two regional analyses of national seed supply systems in Latin America (#41) and Africa (#47).

3.1.2 Capacity building (13 answers)

This sub-category gathers the projects and activities contributing to build capacities at different levels (local, national and regional: see #8) through the promotion of a specific combination of

- innovative tools, techniques and practices, such as sustainable land and water management tools and practices (#14, #57); analytic tools on land degradation dynamics, 13 including mobile tools such as the "Regreening Africa app" for real-time tracking of project indicators (#73); disaster risk reduction methods (#59, #60); adequate tree seed portfolios (#10, #53); and the Integrating Gender and Nutrition within Agricultural Extension Services toolkit (#76);
- institutional changes, such as value chain development (#73), participatory rangeland management (#39), participatory governance mechanisms and/or multi-stakeholder innovation platforms (#9, #11, #14, #40).

3.1.3 Field research/case studies (11 answers)

This sub-category includes case studies aiming at learning from past successes and evaluating possible restoration options. These case studies seek to overcome current barriers and scale up restoration initiatives (#5, #15, #22, #26, #74) or to link broader research frameworks to on-the-ground experiments and implementation (#18). This sub-category also includes five case studies focusing on land tenure security in Madagascar and Ethiopia (#7), Laos (#17, #29) and Myanmar (#16, #48).

3.1.4 Ecological infrastructures piloting or scaling-up (3 answers)

This sub-category includes three projects aiming at building the ecological infrastructures needed for land restoration, such as "green walls" and wind breaks to stop desertification and soil erosion (#2, #3) and water harvesting structures to address water scarcity and land degradation (#13).

13 In particular, this project (#73) uses the Land Degradation Surveillance Framework (LDSF framework) described in project (#77), see Annex.

3.2 Thematic categories: Topics covered

The broad definition of restoration adopted for this survey (see **Section 2.1** on the scope) encompasses any kind of ecosystem. Thus, one could consider that most, if not all, CGIAR research projects contribute, directly or indirectly, to forest and landscape restoration. In particular, all the projects striving for sustainable intensification or sustainable land management can be classified under the first level of restoration intensity (i.e. "ecological intensification", see **Section 6.4.1, Box 2**).

However, it seems useful to distinguish in this synthesis two categories of CSPs:

- "restoration-focused projects" where forest and land degradation is the main entry point and restoration is the main objective.
- "restoration-related projects" that can contribute to forest and landscape restoration while following other objectives (such as sustainable intensification or climate-smart agriculture). In these projects, restoration can appear as a secondary objective or as a co-benefit of the project. These projects can also promote an enabling environment likely to facilitate future restoration efforts.

Of the 39 CSPs analysed, 24 projects have restoration as their main focus, while 15 focus on other issues more or less directly related to restoration.

3.2.1 Restoration-focused projects (24 answers)

These answers can be grouped around five main topics:

Assessing and/or upscaling landscape restoration (12 answers)

A main objective of these projects is to identify and assess restoration practices to learn from (#22, #74) and scale up (#5, #73, #76) successful experiences. For instance, two projects focus on the practice of enclosing degraded lands in Tanzania (#26) and Ethiopia (#56). The projects in this category cover various agroecosystems, including degraded forests and agroforestry in Ethiopia (#5); agroforestry in Vietnam (#74); dry rangelands in Ethiopia (#15); dry forest in Colombia (#20); and steep hillsides and wetlands in the Tana Basin, Kenya (#58). Some projects compare restoration practices and initiatives across different countries or provinces (#19, #22, #69, #73), while others compare the performance of different restoration interventions in the same ecosystem (e.g. #5, #74).

Seeds and genetic diversity (6 answers)

Two projects focus on capacity building and organization of the seed sector. They aim at delivering adequate planting material for forest restoration to enhance productivity, and hence food security and nutrition, income and livelihoods resilience for poor smallholder households (#10, #53). Four projects assess the performance of seed supply systems for landscape restoration at different scales (#21, #41, #42, #47). According to the respondents, four projects are still at a too early stage of development to be fully analysed here (#10, #21, #42, #47).

Climate change and climate-smart restoration (4 answers)

One project uses demonstration and trial plots to identify suitable species for bioenergy production on degraded land that contribute to climate change mitigation, while providing a range of socio- economic and environmental benefits (#4). Another one assesses carbon stocks, greenhouse gas (GHG) fluxes, and rates of sedimentation and subsidence in mangrove and peatland ecosystems across the tropics. This aims to estimate their state of degradation and restoration needs (#6). Two other projects aim at creating climate-smart landscapes through integrated land and water management practices and capacity building at different scales in the Gambia River Basin (#8) and Ethiopia (#57).

Combating desertification and sand fixation (2 answers)

The "Great Green Wall" is a regional initiative for the Sahara and the Sahel, endorsed in 2007 by the African Union Assembly of Heads of States and Governments. It combats

desertification and aims to transform the lives of millions of people (#2). Since 1959, around 10,000 ha of trees were planted along 185 kilometers (km) of the coastline between Dakar and St. Louis, Senegal. The project aims to protect local vegetable irrigated production systems (niayes) and road access from sand dune encroachment (#3).

3.2.2 Restoration-related projects (15 answers)

These answers can be grouped around five main topics:

Land tenure security and land governance reform (5 answers)

These projects focus on land tenure security as a critical factor of restoration. They try to link farmers' strategies to strengthen their land rights at local level with land governance reform at the national level (#7, #16, #17, #29, #48). In Myanmar (#16, #48), international donors have used key findings from the research to help guide ongoing land governance reform. In Laos (#17, #29), the research presented land-use planning as a power game, then incorporated it as part of the teaching program in national universities in Laos and Thailand.

Sustainable land management (4 answers)

These projects contribute to capacity building at local level by promoting sustainable practices and technologies and participatory governance mechanisms (#9). They implement or scale up collective approaches such as participatory rangeland management (#39) or joint village land-use planning (#40). They contribute tobuild multi-stakeholder decision-making bodies, such as innovation platforms and village development committees (#11).

They focus on agroforestry and forestry systems in Sulawesi Indonesia (#9), arid districts of Western Rajasthan in India (#11) or on rangelands in Ethiopia, Kenya and Tanzania (#39, #40). They all aim at improving incomes and livelihoods of farmers and local communities.

Climate-smart agriculture (3 answers)

Two projects aim at building resilience and adaptation to climate extremes and disasters (BRACED Programme) in agricultural landscapes in Chad (#59) and in cocoa production in Ivory Coast (#60). The last project assesses climate-smart agricultural practices at farm and landscape levels on two sites in Ethiopia (#70).

Smart water management (2 answers)

Smart water management (SWM) can help address water scarcity, recharge groundwater reserves and improve land productivity. Low-cost water harvesting structures can limit surface run-off and ensure a reliable water supply all year long (#13). By monitoring soil moisture and nutrients, SWM tools help farmers optimize fertilizer application and irrigation, thus increasing water productivity and profitability (#14).

Collective farming (1 answer)

This research from the IWMI explores how collective farming can drive agricultural productivity without further marginalizing smallholders who individually cannot participate in the transition from subsistence to commercial agriculture proposed by the government in Nepal. It aims at identifying strengths and weaknesses in the ongoingadoption of collective farming (#18).

4 Tools for development (T4D)

This category gathers 22 answers that aim at elaborating tools that can facilitate decision making and/or stakeholder negotiations e.g. models, guidelines and manuals, indicators and metrics, and soil and water management tools. Two functional sub-categories can be distinguished, namely decision-making supporting tools; and models and maps. The second category can also serve as the first layer for decision-making supporting tools as needed.

4.1 Decision-making supporting tools (8 answers)

This sub-category regroups tools, methods and guidelines, directed at decision makers or restoration practitioners at different levels, to support decision making.

Between 2014 and 2018, Bioversity International developed a tool for guiding species and seed selection to improve the effectiveness of restoration under climate change in Colombia's tropical dry forest (#31). This project needs to be finalized and its results communicated.

Three projects from Bioversity International aim to develop tools for laying the foundations for climate-smart restoration of tropical dry forests in Peru (#30) and Burkina Faso (#32), as well as in savanna zones and forest/savanna mosaic landscapes in Cameroon (#33). All these tools aim at improving the effectiveness of restoration under climate change by considering suitability of species and genetic origin. The project in Burkina Faso (#32) puts a particular emphasis on food tree species for nutrition-sensitive restoration. All these projects started in 2018 and are not advanced enough to be more deeply analysed at this stage.

The FORLAND project (#51), led by ONF-I, also falls under this sub-category. This project, a collaboration with CIRAD and ETH-Zurich, is funded by the European Institute of Innovation & Technology. It will develop a new spatial, participative and easy-to-use land-use decision-making tool, whose first module will focus on landscape restoration. Future modules should include FORLAND Sustainable Forest Management (SFM); FORLAND Environmental, Social and Governance (ESG); and FORLAND REDD+. Similarly, CIAT is developing, first in Ethiopia, a "Landscape Doctor" (#64), i.e. a set of decision tools to be used by planners, investors and other decision-makers for initial diagnosis, as well as for solution design and implementation, considering site and context specificities.

Finally, ICRISAT is developing good practice guidelines for restoring productive capacity of dryland in Niger, as well as tools, methods and guidelines for scaling these good restoration practices (#12). The final objective is to reduce food insecurity and improve livelihoods of poor people in African drylands. To that end, the project aims to restore degraded land, thereby increasing land profitability, as well as landscape and livelihood resilience. Likewise, ICRAF published a working paper in 2018 that presents a decision analysis methods' guide. It can help decision makers enhance the effectiveness of agricultural policy for nutrition and allocate resources more efficiently (#68).

4.2 Models and maps (14 answers)

This sub-category regroups maps and models, measuring at different scales the intensity of degradation (i.e. efforts needed for restoration) or modeling the impacts of different land-use changes or land management practices.

This sub-category includes six tools developed by WLE to model and map soil information. These tools comprise soil information maps (#61, #65, #67); a bush encroachment map in Namibia (#62); risk maps of soil nutrient deficiencies in two villages of Western Kenya (#63); and a soil organic content computation tool available in open-access through a mobile phone app (#66). Three tools focus on Africa (#61, #62, #63), while three are applicable anywhere (#65, #66, #67).

Since 2005, ICRAF has developed the Land Degradation Surveillance Framework (LDSF) and applied it in over 250 landscapes (100 km^2 sites) across more than 30 countries (#75, #77). The LDSF provides a field protocol for assessing soil and ecosystem health[14] to help decision makers to prioritize, monitor and track restoration interventions (#75, #77). The nested hierarchical sampling design used in the LDSF is useful for developing predictive models with global coverage, while maintaining local relevance (#77).

One CIFOR project (#23) aims to map the forest biomass accumulation potential as a proxy for climate change mitigation potential in Latin America. It uses a minimum mapping unit of approximately 6 ha. The resulting map, in publication, will be directed to governments and donors interested in prioritizing hotspots in degraded forested landscapes in Latin America. Another project (#54) produced a "vegetation map" that covers eight countries in Eastern and southern Africa. When complemented by a species selection tool, this map can help restoration practitioners to "find the right tree for the right place."

ILRI provides two answers that describe models of rangeland/grazing management developed at local/landscape (#27) and global (#28) scales. Three SWAT[15] models of grazing management (#27) were constructed in collaboration with and based on the knowledge of local and regional partners and institutions in the Lower Tana River Basin (Kenya) and in Yatenga province (Burkina Faso). Government officials (at national and local levels) use these models to develop legislation on rangeland management in consultation with local communities and nongovernmental organizations (NGOs). ILRI also developed a G-Range model of rangeland management (#28), applicable at global scale over long-term horizons. This helps formulate policy decisions based on projected future rangeland conditions and long-term system production potential, under climate change.

Since 2014, in Apurimac (Peru), CIRAD and CIFOR have been developing and applying several methods for analyzing, modeling and mapping the effects of forest-cover change on multiple ecosystem services and their implications for human well-being. They are also developing methods to analyse the trade-offs between these ecosystem services (#24).

IFPRI is developing an analytical model to assess the economics of land degradation (ELD), based on 12 case-study countries[16] (#72). This ELD approach not only considers the conventional market value of crop and livestock products lost because of land degradation but seeks also to capture the loss of terrestrial ecosystem services.

14 Using indicators such as vegetation cover, structure and floristic compositions, tree and shrub biodiversity, historic land use, visible signs of land degradation, and physical and chemical characteristics of soil (including soil organic carbon content and infiltration capacity).

15 Soil & Water Assessment Tools.

16 i.e. Argentina, Bhutan, China, Ethiopia, India, Kenya, Malawi, Niger, Russia, Senegal, Tanzania and Uzbekistan.

5 Approaches and conceptual frameworks (ACF)

This last category, comprising 12 answers, covers more theoretical work. It includes evaluations, conceptual frameworks, systematic literature and/or project reviews, as well as meta-analyses. Two functional sub-categories can be distinguished: (i) conceptual approaches and frameworks; and (ii) systematic reviews.

5.1 Conceptual approaches and frameworks (8 answers)

This sub-category comprises projects and activities aiming at developing or applying integrated, conceptual or theoretical frameworks around FLR and related issues.

It includes four studies focusing on seeds, genetic resources and genetic diversity. One study (2018 –2022) is (i) developing indicators of genetic diversity of native tree species; (ii) building a theoretical framework for planning genetic conservation units for native tree species in South-Eastern Asia, as a foundation of resilient seed systems; and (iii) examining the social barriers to resilient community-based seed system establishment for restoration (#43). Another one (2018 – 2019) develops a theoretical framework for the economic evaluation of genetic diversity in forest landscape restoration using economic simulation models (#46). According to respondents, both projects are still at the inception phase. Another project (#45) is a thematic study for the State of the World's Forest Genetic Resources (FAO 2014). It aims to help restoration practitioners, policy makers and scientists to better understand the importance of genetic diversity for restoring viable and resilient forest ecosystems. It also helps better integrate key genetic considerations into restoration practices, policies and strategies. The fourth answer (#55) presents an integrated flagship approach to manage tree genetic resources in support of forest and landscape restoration — from conservation and domestication to delivery.

One study (#35) proposes an integrated framework to assess or design "climate-smart restoration", based on a review of multiple projects. The objective is to guide decision makers in analyzing the contribution of restoration to climate change strategies and in managing the trade-offs between adaptation and mitigation.

The last three answers refer to conceptual approaches that are not strictly focused on restoration. ICRAF (#37) seeks to improve land management and enhance livelihoods in Indonesia through a farmer-to farmer approach. CIMMYT developed an integrated flagship approach (#36) to boost sustainable intensification of crop systems (wheat and maize). CIAT focuses on sustainable intensification in farming communities, trying to improve on-farm soil fertility; off-farm soil and water conservation; and carbon, water and nutrient cycles in the landscape (#71).

5.2 Systematic reviews (4 answers)

This sub-category includes systematic literature and/or project reviews and meta-analyses on different topics linked to restoration.

Since 2008, CIRAD and CIFOR (#25) have realized several meta-analyses or systematic reviews at different scales — from plot and

watershed to region and continent, on the impacts of forest restoration on water flows, soil erosion, soil mass movements and local to regional climate, with the view to guide decision-making on land management and restoration.

Between 2015 and 2017, Bioversity International realized a global survey on seed sourcing practices for restoration (#44). This was based on a review of 136 restoration projects across 57 countries. It identified typologies of projects and of their seed sourcing practices and assessed how these practices affect restoration outcomes (Jalonen et al. 2018).

The two last studies, which focus on landscape restoration, are based on systematic reviews of literature and restoration projects. CIFOR (#34) examines the links between restoration, adaptation to climate change, food security and nutrition. For its part, ICRAF (#38) explores the principles of good governance in restoration projects, as well as related institutional dynamics, development challenges and needed incentives.

These four studies explicitly seek to guide decision making on land management and restoration. To that end, they develop high-level policy recommendations for governments, international organizations, political decision makers or restoration practitioners involved in land management and land restoration.

6 Discussion: Restoration options in contexts

Based on elements identified by respondents during the survey, this section will initiate a discussion toward a categorization of various restoration options in different contexts (which would also need to be categorized). When needed, the discussion will refer to specific contributions as numbered in **Appendix 2**. Where appropriate, this discussion will also use the conceptual framework discussed during the joint Nairobi workshop. In particular, it will draw on the list of questions presented by Meine van Noordwijk and illustrated in **Figure 4**.

6.1 Why? Achieve the final goal of restoration efforts

According to respondents, the final goal of restoration efforts is to ensure the sustainable management of land and natural resources. In this way, they would contribute to enhance human well-being and achievement of the 2030 Agenda for Sustainable Development (UN 2015). In this section, the objectives inferred from the answers are mapped against the 17 Sustainable Development Goals (SDGs).

Figure 4. Restoration process

Source: Adapted from Presentation of Meine van Noordwijk in FTA/PIM/WLE (2018), van Noordwijk et al. (2020).

Of course, all restoration projects and activities shall directly contribute to "protect, restore and promote sustainable use of terrestrial ecosystems, (...) halt and reverse land degradation" (SDG15). However, the answers show that forest and landscape restoration is a cross-cutting effort. As such, it is likely to be instrumental to achieve not only SDG15, but also most of the SDGs:

- reduce poverty (#12, #15, #56, #76) and improve income and livelihoods (#29, #34, #36, #37, #56, #69, #70, #73, #74) of poor people (#12, #76) and local/rural communities (#2, #11, #9, #58, #69); and strengthen landscape and livelihoods resilience, including to climate change, in particular for poor and vulnerable communities (#2, #8, #12, #36, #45, #53, #55, #69, #70, #73, #76) [SDG1]
- improve food security and nutrition (#12, #15, #34, #36, #53, #58, #68, #73, #76) and health (#36); and boost land productivity and profitability (#12; #36, #76) [SDG2 & 3]
- build capacities (#8, #9, #10, #11, #14, #39, #40, #52, #53, #57, #59, #60, #62); link knowledge with action (#9) by generating and sharing knowledge adapted to local situation (#10, #14, #27); improve knowledge sharing through nested communities of practices (#76), farmer-to-farmer approaches (#37) or horizontal knowledge transfer (#41); and improve youth inclusivity (#36) [SDG4 & 8]
- address social justice, and improve equity and gender equity (#36, #76) [SDG5 & 10]
- address water scarcity; ensure sustainable water management; improve irrigation water productivity; and profitability (#13, #14, #25, #57, #58) [SDG6]
- protect cultural rural heritage (#2); and strengthen risk management (#36), including for climate extremes and natural disasters (#24, #59, #60) [SDG11]
- combat climate change and its impacts, and promote climate-smart restoration (#30, #31, #32, #33, #35, #57, #70), contributing to adaptation (#6, #8, #34, #35, #59, #60), mitigation (#4, #6, #23, #35), including through bioenergy production (#4) and carbon sequestration in biomass and soil (#23, #66) [SDG13 & 7]
- ensure forest protection and combine both protection and production functions of the ecosystem (#29); ensure zero net land degradation (#72); combat desertification (#2, #3); protect genetic resources and enhance genetic diversity (#10, #21, #31, #41, #42, #43, #44, #45, #46, #47, #52) [SDG15]
- reduce conflicts over land (#40) and natural resource use — e.g. water irrigation (#14) — and increase willingness to engage in collective action (#14), participatory governance mechanisms and multi-stakeholder partnerships (#9, #11, #39, #40) [SDG16 & 17].

6.2 What? Address the drivers of current and past degradation

Multiple drivers of forest and landscape degradation are identified in the answers to the survey. They can be grouped in four broad categories: biophysical drivers; unsustainable land use and land management practices; socio-economic drivers; and policies, infrastructure and institutional drivers.

6.2.1 Biophysical drivers

As stated above, degradation refers to the loss of ecological functionality of a given ecosystem, usually considered from a human perspective. In turn, the loss of ecological functionality can be traced back to different forms of degradation of biophysical components of the ecosystem (soil, water resources, vegetation cover). These are often both a result of land degradation and a driver of further degradation of ecological functionality.

Climate, water availability and poor soil are the main biophysical drivers of land degradation highlighted by respondents. In their answers, respondents mentioned the following drivers or processes of degradation linked to biophysical conditions:

- **Climate and climate change** (#21, #28, #30, #31, #32, #33, #36, #70, #73); increasing temperature and declining moisture index in the ecosystems (#8); drought and high climatic variability (#11); high temporal variations generate surface water runoff and unproductive evaporation (#13); and atmospheric CO2 increase (#28)

- **Water scarcity** (#13) and groundwater depletion (#36)
- **Soil**: soil health (#36): soil erosion (#5, #36; #57, #59, #60, #64; #69, #70, #73, #75); topography (#73, #75); desertification (#2, #12) and sand dune encroachment (#3); loss of soil organic carbon (#66); nutrient mining/depletion (#57, #60, #63, #64, #69, #70); soil structure and soil water holding capacity (#13); and siltation and sedimentation (#6, #58).

These poor biophysical conditions can combine with, trigger or aggravate further causes of degradation, including:

- erosion of genetic diversity (#45)
- poor agricultural and livestock productivity (#13, #15);
- shrub/wood/bush encroachment (#15, #21, #28, #39, #40, #62); proliferation of invasive species (#39, #40); and pest outbreaks (e.g. cocoa swollen shoot virus, #60)
- fire (#4, #15, #23).

6.2.2 Unsustainable land-use and land management practices

Unsustainable use of natural resources (land and water), and unsustainable management practices in forestry and agriculture can exacerbate forest and landscape degradation (#11). More precisely, among these drivers, the answers highlighted:

- Land-cover change and land clearing (#73): deforestation (#2, #5, #36, #56, #64, #70) and forest degradation; illegal logging (#8); indiscriminate wood cutting (#2); agriculture encroachment on forests and other natural ecosystems (e.g. savannah, rangelands) (#8, #20, #22, #26, #27, #58, #64); and vegetation clearance (#59)
- Unsustainable agriculture practices (#14), including overgrazing (#2, #20, #21, #22, #23, #26, #56, #64, #73) or “intense and disorganized grazing” (#15, #27, #28); use of fire as a land management tool (#2; #36, #73); monoculture (#75); and lack of specific diversity in farming landscape (#53, #76).

6.2.3 Socio-economic drivers

In some places, the wider socio-economic context can reinforce the consequences of poor biophysical conditions or limited natural resources endowment, exacerbating forest and landscape degradation. Although respondents seem to have paid less attention to this category, they identified demographic dynamics, livelihoods and education as the main socio-economic drivers of land degradation. In particular, the respondents mentioned:

- **Demographic** dynamics: overpopulation (#14) and high population density (#11); settlement expansion (#26); out-migration (#11); and abandon of agricultural lands (#4) that might also be a consequence of degradation
- Poor **livelihoods** (#2, #29, #34, #36, #37): poverty (#8, #12, #15, #56) leading to weak local capacities and low landscape and livelihoods resilience (#2, #8, #11, #12, #36, #45)
- Limited **education**: lack of appropriate knowledge, tools, skills and know-how (#14, #18, #39, #40, #54); and sectoral silos perpetuating fragmented extension services (#18).

6.2.4 Policies, infrastructure and institutional drivers

Appropriate infrastructures, from physical infrastructures to more immaterial assets; adequate level of investments; land tenure security; and, more generally, policies building a conducive institutional environment at national and local levels are critical to halt and reverse the effects of past and current land degradation. All these institutional dynamics (#38) can be associated with asymmetries (#18) in power structures and power relationships (#16, #17, #29).

As institutional drivers of forest and landscape degradation, the answers identified in particular:

- Poor **infrastructures**: limited access to markets (#3, #11, #15); lack of appropriate seed supply systems for restoration (#10, #44, #47); and quality and genetic diversity of seed collection and seedlings (#42).

- Unsustainable/limited **investments** to implement restoration at scale (#15; #39, #40, #52, #56, #57): limited public funding for restoration (#3); limited resources for research and modeling (#27); and lack of smallholders' investments in land management practices (#18).
- **Land tenure insecurity** emerges from the survey as a critical driver of forest and land degradation (#5, #7, #16, #17, #29, #39, #40). The answers highlighted the following issues: weak understanding of customary land and tree tenure arrangements (#2); individualization of the commons (#15); inequal access to land: land accumulation by the minority landlords (#18); lack of regulated land market (#18); and large-scale land acquisition for commercial use (#16, #48).
- Weak **governance**: weak regulatory context and institutions (#56), at national and local levels, generating unclear sharing of responsibilities (#3); poor implementation of policy and legislation (#40); institutional barriers to intersectoral dialogue (#24); armed ethnic conflicts (#16); and conflicts over land and natural resources (#14, #40).

  At the local level, respondents highlight weak local institutions (#11); diminishing customary authority (#39, #40); limited engagement with local communities (#3, #56); implementation barriers to efficient local land-use planning (#29); and social barriers to resilient community-based seed system establishment for restoration (#43).

6.3 Who? Act for forest and landscape restoration

In the CSP template (**Appendix 1**), there was no specific demand on the actors responsible for or affected by past and current land degradation or by restoration efforts. In the T4D and ACF templates, one question focused on the effective or potential end-users of the tools and conceptual approaches developed, generally: donors/investors (#23, #31, #39, #57, #64, #69, #77) and development organizations (#57, #69); policy makers and decision makers across sectors at different levels (#24, #30, #31, #33, #35, #45, #64, #68, #69, #77); scientists (#24, #28, #35, #45, #62, #66, #70, #75, #77) and development-oriented researchers (#68); and restoration planners and practitioners (#31, #32, #33, #45, #54, #64), including farmers and extension officers (#63, #71).

The replies give some elements of answer to the following questions around the "Who?":

- "Who does?": who are the actors of past and current degradations and of restoration efforts?
- "Who cares?": who bears the costs, who reaps the benefits, how equitable are restoration interventions (#19)?
- "Used by whom?": who are the end-users of restoration tools and approaches?

To categorize these stakeholders two complementary approaches can be followed, described below.

6.3.1 A rights-based approach

A human rights perspective makes a fundamental distinction between "right-holders" (i.e. citizens, particularly the most vulnerable) and "duty-bearers" (mainly states with the obligation to respect, protect and fulfill citizens' rights). Violations of human rights, by states or non-state actors (including private actors), must also be considered (HLPE 2018).

Land degradation and restoration efforts particularly affect the rights (including right to food; water sanitation and hygiene; and land tenure security) of those people, often among the most vulnerable and food insecure people, that depend exclusively or importantly on natural resources for their subsistence and livelihoods. These include farmers (#2, #11, #16, #58, #74, #75) and farming households (#13, #14, #17, #21, #53, #73, #74, #76), in particular smallholders (#4, #14, #18, #36, #53, #58, #71, #73) and landless households (#18); herders (#2) and pastoralists (#11, #15); hunters (#2); poor people (#8, #12); women (#9, #11, #19, #39, #40); youth (#36); and forest-dependent people[17] and Indigenous peoples.

17 Comprising (i) people living in and around forests, heavily dependent on forest resources for their livelihoods; (ii) people living in proximity to forests, regularly using forest products for their own subsistence and partly for income generation; and (iii) people engaged in such commercial activities as hunting, collecting minerals or forest industries such as forest management and logging (HLPE 2017).

6.3.2 A multi-stakeholder approach

The answers mention actors belonging to the three "spheres of society" (HLPE 2018):

- **Public sector** (#58): UN agencies, such as IFAD (#3, #77); international donors (#16, #77) such as the Global Environment Fund[18] (#34) and the World Bank (#25, #34); regional intergovernmental organizations such as the European Union (#39) or the African Union (#2); governments, including states, sectoral and/or local administrations (#3, #4, #9, #13, #15, #16, #17, #23, #27, #40, #41, #62, #66, #73, #74, #77); national development agencies (#3, #7, #10, #39) and other public agencies (#32); and international and national research institutions or universities (#11, #13, #17, #29, #39, #62, #70, #75, #77)
- **Private sector** (#20, #58, #74): private industries (#4, #11); cooperatives (#18, #39); and private foundations (#13)
- **Civil society organizations** (#9, #48): NGOs (#11, #27, #39, #40, #57, #66, #76, #77) and all other non-profit organizations or bodies, including local/rural communities (#2, #3, #5, #7, #9, #11, #16, #26, #40, #53, #56, #57, #58, #66, #71), village development committees, commodity specific sub-committees for women (#11) and women farming groups (#76).

In that sense, multi-stakeholder partnerships, bodies or innovation platforms mentioned in the answers (#11, #14, #22, #58) cover many kinds of collaborative arrangements among stakeholders from two or more different spheres of society (HLPE 2018). Note that, depending on their statutory objectives and legal status, research institutions and farmers' organizations can fall under any of the three spheres mentioned above.

6.4 How? Design performant restoration interventions

There is no "one-size-fits-all" solution in forest and landscape restoration. Decision makers and practitioners must choose, among a wide range of restoration options, the solution best adapted to the local, biophysical, institutional and socio-economic context. In so doing, they must consider the potential of the land and the needs of local communities.

The Global Partnership on Forest and Landscape Restoration (GPFLR) has proposed for the Bonn Challenge a broad typology of restoration options. This typology is based on three main categories of degraded land: (i) forested land; (ii) protective land and natural buffers;[19] and (iii) agricultural land. Different restoration options are available in each category, including:[20]

- **in forested land**: silviculture (tree planting) vs. natural regeneration
- **in protected land and natural buffers**: watershed protection and erosion control; or mangrove restoration
- **in agricultural land**: agroforestry; or improved fallow.

Building on survey results, it is possible to deepen the analysis. Restoration interventions, from conceptual to more pragmatic approaches, can be categorized in several ways. The first two options (**Sections 6.4.1** and **6.4.2**) are presented briefly, while the third approach receives more attention (**Section 6.4.3**).

6.4.1 By restoration intensity

Bioversity International (#20) is trying to evaluate the cost-efficiency of **active** versus **passive** restoration interventions in Colombian tropical dry forest over 15 years (2015 – 2030). It examines a range of restoration options – from natural regeneration to assisted natural regeneration; and from low diversity to high diversity plantings – to restore native forest vegetation on lands in different stages of degradation.

More precisely, following the proposal of Meine van Noordwijk discussed during the Nairobi joint workshop, restoration interventions could be classified along four levels of **restoration intensity (Box 2)**. These are also linked to increasing degrees of land/forest degradation intensity:

18 http://www.globalenvironmentfund.com/

19 Such as slopes, rivers, wetlands or coastal areas.

20 www.bonnchallenge.org/content/restoration-options

i. ecological intensification (e.g. #9, #11, #14, #15, #36, #39, #40, #57, #59, #60, #70, #73, #74, #76)
ii. recovery/regeneration (e.g. #26, #56)
iii. reparation/recuperation (e.g. #2, #3, #4, #8, #13, #21)
iv. remediation (no answer).

Box 2. Four levels of restoration intensity

i. **Ecological intensification:** where improvements to the resource base are possible *within existing land use* by combining provisioning, regulating and regenerative aspects of agroecosystem functioning, within a context of supportive input and output markets.

ii. **Recovery/regeneration:** where forms of fallow, resting land, exclosures protected from overgrazing, fire control and assisted natural regeneration can bring back conditions within which ecological intensification is possible. This category often entails change in land use, at least temporarily.

iii. **Reparation/recuperation:** where more intense action than recovery/regeneration is performed (e.g. tree planting) with additional external support, e.g. by creating access to nurseries for diversified germplasm, knowledge not locally available, inputs (including soil amendments) not currently used, supporting local institutions (and bridging social capital with institutions outside the landscape) not currently effective and/or changing tenurial relations with the state or private sector.

iv. **Remediation:** where past activities such as mining, soil pollution or deep drainage have created obstacles to safe agricultural production that require intense specific, often externally supported and financed, efforts and economic reparation.

Source: Presentation of Meine van Noordwijk in FTA/PIM/WLE (2018).

6.4.2 By scale and leading/funding partner

Building upon some of the answers, a more pragmatic approach to sort out restoration interventions could be adopted. They could be classified by **scale** (local vs. national, regional and global approach) and **leading or funding partner** (public, private or civil society organization: see **Section 6.3**). See for instance:

- "community-led solutions for sustainable land management in Western Rajasthan in India" (#11)
- a "household-based restoration approach promoted by local association in Burkina (tiipaalga)" (#21).

6.4.3 By domains of intervention

The answers to the survey also suggest another pragmatic approach to the typology of restoration interventions, which could be classified by domains of interventions. Such an analysis could contribute to illustrate and refine the above-mentioned conceptual typology around restoration intensity.

The following categories of restoration projects and activities can be identified, building on replies to the survey and on previous discussions (**Sections 3 to 5**):

Sustainable management practices

This category gathers restoration interventions, mainly at plot and farm level, aiming at improving the management practices of land and other natural resources (water, energy, biodiversity...), in order to improve productivity, resource-use efficiency and resilience (#10). These restoration interventions refer mostly to the first levels of intensity mentioned above — (i) ecological intensification and (ii) recovery/regeneration — and often operate within existing land use.

In this category, the answers mention for instance:

- farmland management (#69); evergreen agriculture (#73); sustainable production (#60); sustainable intensification and productivity enhancement interventions (forestry, agriculture and/or livestock)

(#10, #11, #13, #15, #36, #39, #40, #71); and effective and sustainable tree, crop and livestock production (#76)
- forest practices such as enrichment planting (#42, #74)
- agroforestry practices (#2, #5, #9, #13, #26, #74) at plot or farm level
- soil and water conservation and sustainable management practices (#11, #13, #36, #57, #58, #69): SWM tools, improving water productivity and profitability, and optimizing fertilizer application in irrigated systems (#14); and grass strips (#58)
- bioenergy production on degraded lands for climate change mitigation (#4).

Many answers in that category highlight diversification (#10, #13), as well as specific and genetic diversity as conditions of resilient restoration (#46). They focus on:
- the suitability of species and genetic origin (#30, #31, #32, #33, #53, #76)
- the use of native tree genetic resource (#30, #32, #33, #43, #45)
- the use of improved (drought-tolerant and higher market value) varieties and cultivars (#11)
- the importance of appropriate seed selection and seed sourcing practices (#21, #32, #44) to deliver appropriate seeds and plants (#10, #31, #43, #52) for efficient restoration interventions.

Integrated landscape management

This category comprises restoration interventions, operating mainly at landscape and/or ecosystem level; adopting a holistic and integrated perspective at landscape level; and building on the synergies between different components of the ecosystems (humans, animals, plants, soils and water) to progress toward sustainability. In this category the answers mention (for instance):
- the Ngitili system, a traditional fodder management system in Tanzania (#26)
- community-based silvo-pastoral systems (#11)
- intersectoral landscape management (#24, #74); integrated tree, crop and livestock production systems (#12, #36, #76); integrating forests and agroforestry land uses (#74)
- creation of climate-smart multi-functional landscapes through integrated soil, land and water management at different scales (#8, #57, #59, #60, #70).

This category of interventions generally involves a range of practices. They can also operate at wider scale. For instance, the "Great Green Wall" is a regional initiative that evolved from the idea of a line of trees into the vision of a great mosaic of green and productive landscapes from east to west across the Sahara and the Sahel (#2).

Infrastructures

This category includes the establishment and maintenance/management of infrastructures such as:
- exclosure establishment, improvement and management (#5, #15, #56); and enclosing collective/communal and/or private degraded areas (#26, #56)
- hillside management (#58, #69); and terraces to control soil erosion and water runoff (#58, #69)
- gully rehabilitation practices, including check dams and cut-off drains (#69)
- reforestation and tree planting, e.g. smallholder plantations (#5)
- "green walls" to combat desertification and act as windbreaks (#2, #3)
- low cost water-harvesting structures and decentralized water harvesting techniques to address water scarcity, allowing a more reliable water supply all year long and increasing productivity (#13).

These interventions can be linked to a change in land use and correspond mainly to the last levels of restoration intensity — (iii) reparation/recuperation and (iv) remediation.

This category also includes the establishment of all the physical or immaterial infrastructures needed to improve
- access to land and natural resources, in particular for women (#9, #40);
- access to markets (#3, #11, #15), including road access (#3) or improved value chains (#9).

Access to markets includes access to goods and services, and to input and output markets. Seeds have been mentioned above as a critical input for restoration. Hence, establishing strong national seed supply systems (#41, #47) or gene banks (#52, #55) can play a crucial role for the efficiency of restoration efforts in a country.

Institutional changes and incentives

Technical changes in land use and land management practices will not be enough. Institutional changes, at local and national levels, are needed to support restoration efforts. The answers try to identify good governance principles, institutional dynamics, development challenges and incentives[21] needed in restoration projects (#38, #56).

They call for renewed engagement in restoration through appropriate **resource mobilization** and sustainable level of **investments** (#3, #15, #18, #27, #36, #39, #40).

They highlight **participatory management** approaches (#5, #29, #36, #39, #56), engagement with local communities (#3, #56, #57) — paying a particular attention to women (#11, #39), and smallholder and landless households (#18) — as well as engagement with local and regional partners (#27), as conditions of success for restoration interventions. Such approaches allow the integration of local knowledge (#27) and facilitate local community (and local government) participation and sense of ownership (#11, #39, #40, #48). Participatory governance mechanisms shall be established at different scales (#9, #11). Participatory governance and **collective action** can be facilitated by producers' associations e.g. the livestock keepers' association (#40) and collective farming (#18); multi-stakeholder bodies (#39) and multi-stakeholder innovation platforms (#11, #14); village development committees; and joint village land-use planning (#40), etc.

They study the **political, legal and administrative frameworks** (#18, #22), as well as the institutional dynamics behind public, private or public-private restoration initiatives (#22). Many projects aim at delivering policy recommendations for decision makers at different levels (e.g. **Section 5.1**) to influence national policy and legislation (#39, #40).

As mentioned above, the answers identify land tenure security as a critical institutional factor of restoration. To address this issue at national level, restoration interventions should aim at improving land governance by supporting land governance reform (#16, #17, #48); and better regulating the land market (#18) and, in particular, large-scale land acquisition for commercial use (#16, #48). At local level, restoration interventions should aim at protecting access to land and natural resources by improving governance of the commons (#11, #40); and considering and preserving local institutional arrangements (e.g. informal land rental arrangements and customary land rights) (#17, #29, #48). For instance, in Tanzania, access to grazing areas is secured through group Certificates of Customary Rights of Occupancy. These are provided through the Sustainable Rangeland Management Program (2016 – 2020), which is managed by ILRI with the financial support of IFAD, the International Land Coalition and the Tanzanian government (#40).

Knowledge generation, knowledge sharing and capacity building

This category includes all the projects that elaborate conceptual approaches and frameworks **generating** theoretical **knowledge** at different scales (**Section 5**), and apply them in different contexts (**Section 3.1**: "field assessments", "field research/case studies"). It includes all the models and tools, sometimes integrating different forms of knowledge, including local knowledge (#27), that support decision making at different scales (from local to global) by different stakeholders (from farmers, restoration practitioners to government officials) (see **Section 4**). Such projects and activities can also contribute to monitoring and evaluation (#10, #18, #41).

21 Including taxes and subsidies.

It also includes all the interventions aiming at **sharing knowledge** through integrated extension services, breaking the sectoral silos (#18), and through innovative learning models such as horizontal knowledge transfer (#41), nested communities of practice (#76) or farmer-to-farmer approaches (#37). This category comprises all the restoration projects and activities aiming to raise awareness or **build capacities** at different scales through the appropriate mix of technological and institutional changes (see **Section 3.1.3**).

7 So what? Conclusion

Beyond forest and landscape restoration, this preliminary analysis identified other salient issues closely linked to restoration: sustainable land management (18 answers) and sustainable water management (2 answers); genetic diversity and seed supply systems (13 answers); climate change — adaptation and/or mitigation — (13 answers); land tenure security and land governance reform (5 answers).

From this preliminary analysis, some aspects seem less covered. For instance, if many projects focus on the technical performance of different restoration practices, only a few focus on the economics of land degradation and restoration (e.g. #19, #20, #46, #72). Few projects investigate power structures, power asymmetries and power games, and most of these focus on land tenure security (#16, #17, #18, #29). One answer (#22) focuses on the political economy underlying the official political discourse and seeks possible ways to unlock the investment constraint. To that end, it tries to better understand the dynamics between regulations and incentives in public-, private- and public-private restoration initiatives in Central America.

The answers received identify five critical factors of success for restoration interventions: (i) secure tenure and use rights; (ii) access to markets (for inputs and outputs) and services; (iii) access to information, knowledge and know-how associated with sustainable and locally adapted land use and land management practices; (iv) status of local ecosystem services, often used as a baseline to assess the level of degradation; and (v) potential contribution to global ecosystem services likely to attract international donors.

This preliminary analysis could be a starting point to elaborate a typology of restoration options in different contexts, at different stages of the forest transition curve. In particular, the previous discussion (**Section 6**) provides some first elements contributing to the description of the different contexts where restoration is needed. This description should include an illustration of current national and local conditions (biophysical, socio-economic and institutional); an assessment of current land use and land management practices; and identification of the main causes of degradation (**Section 6.2**) in a given context. **Section 6.4** then suggests some elements of answer to the “How?” question, presenting different kinds of restoration interventions. **Section 6.1** illustrates how the SDGs could constitute an overall framework in which could be inscribed such a typology.

Further collaborative activities could be developed among the three CRPs on the themes highlighted above. This preliminary analysis also identifies some countries concentrating many answers where such collaborations might be easier and fruitful.

8 References

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9 Appendixes

Appendix 1. Survey templates

Appendix 1.1 Restoration project

Name of respondent and e-mail:
Center:
CRP/Flagship (if relevant):

Title:
Starting year:
Ending year:
Place:

1a) Scale:
Plot
Farm
Landscape

1b) Driver of degradation addressed/reversed

1c) Stage of the forest transition curve
Forested landscape
Agriculture
Agroforestry

1d) Entry point:
Biophysical (soil, vegetation)
Economics, livelihoods
Governance, institutions
(ranked from 1 to 3 if there are multiple objectives)

2) short description of the project (2-5 lines)

3) results
Impacts: positive, failure, unexpected impacts (positive or negative)
What has helped?
Main constraints?
Evidence of impact

4) References

Appendix 1.2 Restoration tool

Name of respondent and e-mail:
Center:
CRP/Flagship (if relevant):

Title:
Year:

1a) Scale:
Plot
Farm
Landscape

1b) Driver of degradation addressed/reversed

1c) Stage of the forest transition curve
Forested landscape
Agriculture
Agroforestry

1d) Entry point:
Biophysical (soil, vegetation)
Economics, livelihoods
Governance, institutions
(ranked from 1 to 3 if there are multiple objectives)

2) Short description of the tool (2-5 lines)

3) Effective use
Where?
By whom?
For what?

4) results
Impacts: positive, failure, unexpected impacts (positive or negative)
What has helped?
Main constraints?
Evidence of impact

5) References

Appendix 1.3 Conceptual approach to restoration

Name of respondent and e-mail:
Center:
CRP/Flagship (if relevant):

Title:
Year:

1a) Scale:
Plot
Farm
Landscape

1b) Driver of degradation addressed/reversed

1c) Stage of the forest transition curve
Forested landscape
Agriculture
Agroforestry

1d) Entry point:
Biophysical (soil, vegetation)
Economics, livelihoods
Governance, institutions
(ranked from 1 to 3 if there are multiple objectives)

2) Short description of the approach (2-5 lines)

3) Used
Where?
By whom?
For what?

4) Results
Impacts: positive, failure, unexpected impacts (positive or negative)
What has helped?
Main constraints?
Evidence of impact

5) References

Appendix 2. Answers to the survey

List of the answers

#	New Functional Category	CRP	CGIAR Center	Respondent	Mail	Title
#1	-	FTA	CIFOR	Dr. D. Andrew Wardell	a.wardell@cgiar.org	Restoration of Mt. Aigoual, Massif Central, France
#2	CSP	FTA	CIFOR	Dr. D. Andrew Wardell	a.wardell@cgiar.org	Stebbing's "two green walls" to stop the encroachment of the Sahara
#3	CSP	FTA	CIFOR	Dr. D. Andrew Wardell	a.wardell@cgiar.org	Sand dune fixation
#4	CSP	FTA	CIFOR	Himlal Baral, Ph.D	h.baral@cgiar.org	Socio economic and environmental benefits of bioenergy production on degraded land
#5	CSP		CIFOR	Habtemariam Kassa	h.kassa@cgiar.org	Identifying good practices in forest landscape restoration and enabling conditions for scaling up
#6	CSP		CIFOR	Daniel Murdiyarso	d.murdiyarso@cgiar.org	Sustainable Wetland Adaptation and Mitigation Program (SWAMP)
#7	CSP	PIM	CIFOR	Steven Lawry		Tenure security and resource governance as factors in forest landscape restoration. ("Restoring Forests, Restoring Communities")
#8	CSP		ICRAF	Lalisa Duguma	l.duguma@cgiar.org	Large-scale Ecosystem-based Adaptation in the Gambia River Basin: Developing a climate resilient, natural resource-based economy
#9	CSP		ICRAF	James M Roshetko	jroshetko@cgiar.org	Agroforestry and Forestry in Sulawesi: linking knowledge with action (AgFor) project
#10	CSP	FTA	ICRAF	Lars Graudal	L.Graudal@cgiar.org	Provision of adequate tree seed portfolios to enhance productivity and resilience of forest landscape restoration in Ethiopia (PATSPO), supported by the Norwegian International Climate and Forest Initiative (NICFI)
#11	CSP	Dryland syst.	ICRISAT	Shalander Kumar; Anthony Whitbread	k.shalander@cgiar.org; a.whitbread@cgiar.org	Community led solutions for sustainable land management in Western Rajasthan in India
#12	T4D	WLE	ICRISAT	Vincent Bado	V.Bado@cgiar.org	Restoration of degraded land for food security and poverty reduction in East Africa and the Sahel: taking successes in land restoration to scale.

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List of the answers (Continued)

#	New Functional Category	CRP	CGIAR Center	Respondent	Mail	Title
#13	CSP	WLE	ICRISAT	Kaushal K Garg	k.garg@cgiar.org	Analysing impact of various agricultural water management (AWM) interventions on watershed hydrology and various ecosystem trade-offs in Bundelkhand region of Central India
#14	CSP	WLE	ICRISAT	Martin Moyo; Andre van Rooyen	M.Moyo@cgiar.org; AvanRooyen@cgiar.org	Improving water productivity and profitability in small-scale communal irrigation schemes in southern Africa
#15	CSP	Livestock	ILRI	Jason Sircely	j.sircely@cgiar.org	Restoration of degraded land for food security and poverty reduction in East Africa and the Sahel: taking successes in land restoration to scale (ILRI component)
#16	CSP	PIM	IWMI	Diana Suhardiman		Linking land tenure security with state transformation processes in Myanmar
#17	CSP	PIM	IWMI	Diana Suhardiman		Linking land tenure security with food security in Laos
#18	CSP	PIM	IWMI	Sanjiv de Silva		Collective Farming for Improving Small Scale Agriculture Performance in Nepal
#19	CSP	FTA/WLE	Bioversity International	Marlène Elias	marlene.elias@cgiar.org	Assessing the socio-economic impacts of restoration initiatives: A cross-regional analysis
#20	CSP	FTA	Bioversity International	Rachel Atkinson; Evert Thomas	r.atkinson@cgiar.org; e.thomas@cgiar.org	Trials to evaluate the cost-efficiency of active versus passive restoration interventions to restore tropical dry forest across a degradation gradient in Colombia
#21	CSP	FTA	Bioversity International	Barbara Vinceti	b.vinceti@cgiar.org	Nutrition-sensitive forest restoration to enhance the capacity of rural communities in Burkina Faso to adapt to change
#22	CSP	FTA /PIM	Bioversity International	Dietmar Stoian	d.stoian@cgiar.org	Overcoming barriers to landscape restoration: Learning from experiences across Central America
#23	T4D		CIFOR	Rosa María Román-Cuesta	R.Roman-Cuesta@cgiar.org	Mitigation potentials in Latin American landscapes through two carbon-intense restoration options: forest expansion and peat restoration
#24	T4D	FTA	CIFOR/ CIRAD	Bruno Locatelli	bruno.locatelli@cirad.fr	Methods and tools to analyse trade-offs between ecosystem services in restoration
#25	ACF	FTA	CIFOR/ CIRAD	Bruno Locatelli	bruno.locatelli@cirad.fr	Meta-analyses on the effects of restoration on water and soils

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List of the answers (Continued)

#	New Functional Category	CRP	CGIAR Center	Respondent	Mail	Title
#26	CSP	FTA	ICRAF	Lalisa Duguma	l.duguma@cgiar.org	Understanding the restoration success in Shinyanga, Tanzania - from a bare degraded land to a rich biodiverse ecosystem
#27	T4D	WLE	ILRI	Jason Sircely	j.sircely@cgiar.org	Enhancing the value of ecosystem services in pastoral systems (EVESPS) project
#28	T4D	CCAFS	ILRI	Jason Sircely	j.sircely@cgiar.org	G-Range global rangelands model
#29	CSP	PIM	IWMI	Diana Suhardiman		Linking land tenure security with food security in Laos
#30	T4D	FTA	Bioversity International	Evert Thomas; Rachel Atkinson	e.thomas@cgiar.org; r.atkinson@cgiar.org	Laying the foundations for climate-smart restoration: a toolbox for Peru's tropical dry forest
#31	T4D	FTA	Bioversity International	Evert Thomas; Rachel Atkinson	e.thomas@cgiar.org; r.atkinson@cgiar.org	A tool for guiding species and seed selection for the restoration of Colombia's tropical dry forest
#32	T4D	FTA	Bioversity International	Barbara Vinceti	b.vinceti@cgiar.org	Laying the foundations for nutrition-sensitive, climate-smart restoration: a toolbox for Burkina Faso's dry forest
#33	T4D	FTA	Bioversity International	Marius Ekue	m.ekue@cgiar.org	Laying the foundations for climate-smart restoration: a toolbox for the mosaic forest/savanna ecotone and savanna zones of Cameroon
#34	ACF		CIFOR	Amy Ickowitz Houria Djoudi	a.ickowitz@cgiar.org; h.djoudi@ cgiar.org	Restoration, Adaptation, Food Security, and Nutrition – what are the links?
#35	ACF	FTA	CIFOR/ CIRAD	Bruno Locatelli	bruno.locatelli@cirad.fr	A framework to understand the multiple (and sometimes conflicting) contributions of restoration to climate change strategies and the opportunities of integrating restoration to adaptation and mitigation strategies
#36	ACF		CIMMYT	Bruno Gerard	b.gerard@cgiar.org	MAIZE: Sustainable Intensification of Maize-based Systems for Improved Smallholder Livelihoods. WHEAT: Sustainable intensification of wheat-based farming systems
#37	ACF		ICRAF	Endri Martini; James Roshetko	emartini@cgiar.org; jroshetko@cgiar.org	Farmer-to-farmer approach
#38	ACF		ICRAF	Peter Minang	a.minang@cgiar.org	Trends of governance in landscape restoration
#39	CSP	PIM	ILRI	Fiona Flintan	f.flintan@cgiar.org	Participatory Rangeland Management
#40	CSP	PIM	ILRI	Fiona Flintan	f.flintan@cgiar.org	Sustainable Rangeland Management Project including Joint Village Land Use Planning

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List of the answers (Continued)

#	New Functional Category	CRP	CGIAR Center	Respondent	Mail	Title
#41	CSP		Bioversity International	Rachel Atkinson; Evert Thomas	r.atkinson@cgiar.org; e.thomas@cgiar.org	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
#42	CSP	FTA	Bioversity International	Christopher Kettle	c.kettle@cgiar.org	Evaluation of genetic diversity of brazil nut seedlings used in restoration of degraded lands in Madre di Dios Peru
#43	ACF	FTA	Bioversity International	Christopher Kettle; Riina Jalonen	c.kettle@cgiar.org; r.jalonen@cgiar.org	Developing indicators for Genetic conservation units of native trees to deliver resilient seed supply systems for priority tree species in S E Asia
#44	ACF	FTA	Bioversity International	Riina Jalonen	r.jalonen@cgiar.org	Global survey on seed sourcing practices for restoration
#45	ACF	FTA	Bioversity International	Riina Jalonen	r.jalonen@cgiar.org	Genetic considerations in ecosystem restoration using native tree species. Thematic study for the State of the World's Forest Genetic Resources.
#46	ACF	FTA	Bioversity International	Christopher Kettle; Elisabetta Gotor	c.kettle@cgiar.org; e.gotor@cgiar.org	Developing a theoretical framework for the economic evaluation of diversity in forest landscape restoration
#47	CSP		Bioversity International	Marius Ekue	m.ekue@cgiar.org	Seed supply systems for the implementation of landscape restoration under AFR100: An analysis of national seed systems in 10 SAFORGEN countries
#48	CSP	PIM	IWMI	Diana Suhardiman		Land governance reform and state transformation processes in Myanmar
#49	O		CIFOR	Manuel R. Guariguata		Essential CIFOR past (and some recent) work on reforestation and rehabilitation
#50	O		CIFOR	Manuel R. Guariguata		Work both recently produced and ongoing
#51	T4D		ONF-I / CIRAD/ETH	Coordinators for Cirad: P. Sist and H. Dessard		FORLAND project synthetic sheet
#52	O		ICRAF	Ramni Jamnadass; Roeland Kindt; Lars Graudal	R.Jamnadass@cgiar.org; R.Kindt@cgiar.org; L.Graudal@cgiar.org	The delivery of planting material for productive forest landscape restoration to bridge production gaps and promote resilience

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List of the answers (Continued)

#	New Functional Category	CRP	CGIAR Center	Respondent	Mail	Title
#53	CSP	FTA	ICRAF	Stepha McMullin	s.mcmullin@cgiar.org	Agro-biodiversity and landscape restoration for food security and nutrition in East Africa (Ethiopia and Uganda)
#54	T4D	FTA	ICRAF	Roeland Kindt	R.Kindt@cgiar.org	Vegetation map for Africa including species selection tools
#55	ACF	FTA	ICRAF	Alice Muchugi	A.Muchugi@cgiar.org	The delivery of planting material for productive forest landscape restoration to bridge production gaps and promote resilience within the framework of FTA FP1 and the Genebank Platform
#56	CSP	WLE	IWMI	Wolde Mekuria	w.bori@cgiar.org	Restoration of degraded landscapes following exclosure establishment in communal grazing lands
#57	CSP	WLE	CIAT			Creating climate-smart multifunctional landscapes through integrated soil, land and water management at different scales
#58	CSP	WLE	CIAT	Fred Kizito		Biophysical and socio-economic synthesis of the effectiveness of land restoration towards enhancing food security and livelihoods in smallholder communities
#59	CSP	WLE	ICRAF	Ermias Betemariam	e.betemariam@cgiar.org	Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) Programme
#60	CSP	WLE	ICRAF	Ermias Betemariam	e.betemariam@cgiar.org	Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) Programme
#61	T4D	WLE	ICRAF	Keith Shepherd	k.shepherd@cgiar.org	Africa Soil Information Service (AfSIS)
#62	T4D	WLE	CIAT	John Mutua		Methodology on bush encroachment mapping
#63	T4D	WLE	CIAT	Kristin Piikki; Mats Söderström	Kristin.piikki@slu.se	Digital soil maps for Mukuyu and Shikomoli -web applications and map books.
#64	T4D	WLE	CIAT			Landscape Doctor
#65	T4D	WLE	CIAT	Kristin Piikki; Mats Söderström	Kristin.piikki@slu.se	Package ‘mapsRinteractive’
#66	T4D	WLE	CIAT	Rolf Sommer		The CIAT SOC App
#67	T4D	WLE	CIAT	Kristin Piikki; Mats Söderström	Kristin.piikki@slu.se	R package: ‘SurfaceTortoise’

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List of the answers (Continued)

#	New Functional Category	CRP	CGIAR Center	Respondent	Mail	Title
#68	T4D	WLE	ICRAF	Keith Shepherd	k.shepherd@cgiar.org	Decision Analysis
#69	CSP	WLE	IWMI	Zenebe Adimassu	z.adimassu@cgiar.org	Highlights of watershed soil and water conservation investments of Ethiopia: impacts, benefits and needs for environment and development
#70	CSP	CCAFS	CIAT			Climate smart villages (CSV)
#71	ACF	WLE	CIAT	Ravic Nijbroek		Scientist
#72	T4D	PIM/WLE	IFPRI	Ephraim Nkonya	e.nkonya@cgiar.org	Global Economic Assessment of Land Degradation and Improvement
#73	CSP		ICRAF	Susan Chomba	s.chomba@cgiar.org	Reversing Land Degradation in Africa by Scaling-up Evergreen Agriculture
#74	CSP	FTA	ICRAF	La Nguyen	l.nguyen@cgiar.org	Developing and Promoting Market-based Agroforestry and Forest rehabilitation Options for Northwest Viet Nam - AFLi2 project
#75	T4D	FTA	ICRAF	Nguyen Mai Phuong		The Land Degradation Surveillance Framework (LDSF) in Son La province, Vietnam
#76	CSP	FTA	ICRAF	Leigh Winowiecki	L.A.Winowiecki@cgiar.org F.Sinclair@cgiar.org	Restoration of degraded land for food security and poverty reduction in East Africa and the Sahel: taking successes in land restoration to scale
#77	T4D	FTA	ICRAF	Leigh Ann Winowiecki; Tor-Gunnar Vågen	L.A.Winowiecki@cgiar.org; T.Vagen@cgiar.org	Land Degradation Surveillance Framework (LDSF)

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FTA WORKING PAPER

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Despite the high level of political engagement and the wide range of organizations involved in restoration projects from local to global levels, beyond some success stories, restoration is not happening at scale. To address this issue, three CGIAR Research Programs (CRPs) – Forests, Trees and Agroforestry (FTA); Policies, Institutions and Markets (PIM) and Water, Land and Ecosystems (WLE) – decided to bring together their expertise in a joint stocktaking of CGIAR work on restoration. This publication illustrates with concrete examples the powerful contribution of forest and landscape restoration to the achievement of most, if not all the 17 sustainable development goals. It can be used to support the design of future restoration activities, programs and projects. We hope that this document will help upscale restoration efforts and deliver enhanced impact from our CGIAR research.

The CGIAR Research Program on Forests, Trees and Agroforestry (FTA) is the world's largest research for development program to enhance the role of forests, trees and agroforestry in sustainable development and food security and to address climate change. CIFOR leads FTA in partnership with Bioversity International, CATIE, CIRAD, ICRAF, INBAR and TBI.

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