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IUFRO World Series Volume 34 – Forest Landscape Restoration as a Key Component of Climate Change Mitigation and Adaptation

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IUFRO World Series Volume 34

Forest Landscape Restoration as a Key Component of Climate Change Mitigation and Adaptation

John A. Stanturf, Promode Kant, Jens-Peter Barnekow Lillesø, Stephanie Mansourian, Michael Kleine, Lars Graudal, Palle Madsen

IUFRO



IUFRO World Series Vol. 34

Forest Landscape Restoration as a Key Component of Climate Change Mitigation and Adaptation

*John A. Stanturf, Promode Kant, Jens-Peter Barnekow Lillesø,
Stephanie Mansourian, Michael Kleine, Lars Graudal, Palle Madsen*

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Preface

Land degradation is a threat to global sustainability and heightened concerns over climate change impacts on ecosystem services underscore the importance of forest land cover as a carbon sink, habitat for biodiversity, and support for livelihoods and quality of life. Recognizing the need for large-scale restoration to counter degradation and improve vital ecosystem functions and services, international initiatives have set various targets for improving forest ecosystems. These include the Bonn Challenge (150 million ha by 2020), the New York Declaration on Forests (350 million ha by 2030), land net degradation neutrality (LDN) by 2030 set by the United Nations Convention to Combat Desertification (UNCCD), and the goal of no net biodiversity loss, and net positive impacts on biodiversity given by the Convention on Biological Diversity (CBD). Their Aichi Target 15 calls for 15% of degraded lands restored by 2020.

To implement the Bonn Challenge and other international commitments that require forest restoration and conservation, the German Environment Ministry (BMU) approved a four-year project led by the World Resources Institute called "Inspire, Support and Mobilize Forest and Landscape Restoration." As one of the partners in this effort, IUFRO is providing scientific information, knowledge and expertise on ecological, social and economic aspects of forest landscape restoration (FLR). This report is the result of a team of scientists from relevant IUFRO units who focused on the potential for FLR to contribute to climate change mitigation and adaptation, the linkages between adaptation and mitigation, and the reciprocal benefits to FLR.

Forest and landscape restoration can contribute to climate change mitigation and adaptation by increasing productivity of landscapes, enhancing the resilience of forest ecosystems, and reducing the vulnerability of forest-dependent human communities. Actions to conserve, sustainably manage, and restore forests can contribute to economic growth, poverty alleviation, rule of law, food security, climate resilience, and biodiversity conservation. Restoring forest landscapes can help secure respect for the rights of forest dependent indigenous peoples, while promoting their participation and that of local communities in natural resources decision making.

Drawing on state-of-the-art scientific knowledge through analysis of restoration case studies and review of scientific literature, IUFRO scientists developed a framework to demonstrate how FLR can contribute to climate change mitigation and adaptation. One of the major results of this study was the identification and detailed description of the many different ways in which FLR contributes to both mitigating climate effects and helping ecosystems and society to adapt to adverse effects of a changing climate. In addition, this work contributed a stoplight tool aimed at better presenting complex restoration initiatives, and how they may contribute to climate change mitigation and adaptation and vice-versa, in a specific local context.

This report represents the efforts of many collaborators besides the authors. The 15 case studies of forest restoration from projects in South and Southeast Asia, East Africa, Europe, Latin and North America that were analyzed are published separately on the IUFRO Website, and we thank the contributors. Throughout the process, the authors relied on the guidance of Lars Laestadius of the World Resources Institute and we are grateful for the stimulating discussions he provided. Stephanie Mansourian did double duty as co-author and editor of the report and case studies; Michael Kleine also performed doubly as co-author and task master, keeping us more or less on schedule and within budget. The assistance by Renate Prüller in proofreading and by Eva-Maria Schimpf and Balazs Garamszegi in the coordination of lay-out and printing is much appreciated. We also acknowledge our respective institutions that supported our involvement. The University of Copenhagen provided a convivial meeting place for several working meetings.

We sincerely thank the reviewers of the report for their valuable comments and suggestions that have greatly improved the quality of the publication: Manuel Guariguata and Rodney John Keenan.

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John Stanturf
Coordinator IUFRO Research Group 1.06.00
"Restoration of degraded sites"

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Executive Summary

With an estimated 25% of the global land surface in one way or another being degraded, and about 15% considered appropriate for forest landscape restoration, the need for large-scale restoration to improve vital ecosystem functions and services has significantly increased in recent years. Action to conserve, sustainably manage, and restore forests can contribute to economic growth, poverty alleviation, rule of law, food security, climate resilience, and biodiversity conservation. Restoring forest landscapes can help secure respect for the rights of forest dependent indigenous peoples, while promoting their participation and that of local communities in natural resources decision making.

Forest Landscape Restoration (FLR) aims to improve the landscape for people and for biodiversity, through several approaches – agroforestry, tree planting, natural regeneration, connecting forest fragments, etc. – so that it can better provide ecosystem services, support biodiversity and withstand threats such as climate change. FLR can contribute to climate change mitigation and adaptation by increasing productivity of landscapes, enhancing the resilience of forest ecosystems, and reducing the vulnerability of forest-dependent human communities. By providing ecosystem services and protecting settlements from extreme climatic events, forest landscape restoration plays an important role in the adaptive capacity of local communities and the broader society. A socio-ecological system that links forest mitigation, forest adaptation and community adaptation can be described in the context of FLR. Interventions related to FLR impact on this socio-ecological system and thus require broad knowledge generated by the bio-physical, economic, social and political sciences.

Numerous examples from around the world show that successful restoration of forest ecosystems is not only technically and economically feasible, but also socially acceptable if prepared and designed with adequate participation of relevant stakeholders. As part of a collaborative project titled "Inspire, Support, and Mobilize Forest and Landscape Restoration" between the World Resources Institute and IUFRO funded by the German Ministry of Environment (BMU), a group of IUFRO scientists has developed a framework to demonstrate how FLR can contribute to climate change mitigation and adaptation. IUFRO's role was to provide state-of-the-art scientific knowledge on FLR through analysis of restoration case studies, review of scientific literature and development of capacity building material. Drawing on state-of-the-art scientific knowledge, this work demonstrates how restoration as both a socio-political process and technical interventions, can help to meet climate objectives. In addition, this work is also intended to contribute to a better understanding of forest and landscape restoration among relevant decision-makers by means of a stoplight tool aiming at a simplified presentation of complex restoration initiatives, and how they may contribute to climate change mitigation and adaptation and vice-versa, in a specific local context.

Reducing emissions from deforestation and increasing forest restoration will be extremely important in limiting global warming to 2°C. Forests represent one of the most cost-effective climate solutions available today. One of the major results of this study is the identification and detailed description of the many different ways in which FLR contributes to both mitigating climate effects and helping ecosystems and society to adapt to adverse effects of a changing climate. The contribution of forest and landscape restoration to climate change mitigation and adaptation consists of a wide array of policy, governance, and operational aspects that need to be addressed before a landscape can be improved to meet desired social, environmental, and economic objectives including those related to climate change.

Forest landscape restoration contributes to a number of current and emerging global and national policies of relevance to climate change. Already several global mechanisms exist to support concrete action towards climate change objectives. Forest landscape restoration and climate-related policy are closely inter-linked: on the one hand, FLR can support achievement of climate-related commitments and on the other climate policies, tools, and funds can accelerate implementation of FLR. Existing global conventions, FLR policy initiatives, and support mechanisms clearly provide a comprehensive framework for action.

The authors assembled from the scientific literature a list of potential FLR activities that could contribute to mitigation and adaptation objectives. Using 15 case studies of forest restoration from projects in South and Southeast Asia, East Africa, Europe, Latin and North America, they found examples of additional activities that could enhance the contribution to climate change mitigation and adaptation. Importantly, the projects in these case studies were not designed with climate change mitigation and adaptation in mind; and not all were truly of a scale to be considered forest landscape restoration. Nevertheless, they provided examples of what is being done on the ground.

The FLR activities were categorized as mitigation or adaptation, realizing that some activities could be considered as both. Additionally, adaptation was further divided into incremental, anticipatory, and transformational approaches. Mitigation takes aim at the causes of climate change, the emission of greenhouse gases (GHG) and their accumulation in the atmosphere. Mitigation interventions either reduce the sources of, or enhance the sinks for GHG. Mitigation activities include carbon conservation and increasing sequestration, offsets through substitution for fossil fuels or unsustainably harvested wood, and by substituting wood products in place of energy-intensive materials such as steel, cement, or plastic. Mitigation has been seen as primarily an international issue; the benefits of mitigation accrue globally, over the long-term because of the inertia of the climate system.

Adaptation focuses on the effects of climate change and is local in nature, with short-term effects on vulnerability of natural and social systems. Forests are vulnerable to climate change and adaptation is needed to maintain their functioning. Adaptation activities relevant to FLR mostly fall into the categories of practice and behavior, green infrastructure, and technology. Practice and behavior refers to revised or expanded practices that relate directly to building resilience, such as thinning stands to reduce transpiration loss as an adaption to drought. Green infrastructure describes new or improved natural infrastructure that provides direct or indirect protection from climate hazards. Planting coastal mangroves to adapt to rising sea levels and protect from storm surges is an example of green infrastructure. Incremental and anticipatory adaptations are appropriate responses to mild to moderate changes in global climate. Severe and abrupt climate change will require more controversial, transformational adaptation.

Transformational adaptations proactively respond to or anticipate climate change, are larger scale or more intense than incremental or anticipatory adaptations, or they are novel by their nature or new to a region. Transformational adaptations include managing novel ecosystems or creating them using assisted migration of species. Many of these transformational adaptations are controversial and most are in the research and development phase, that is, they have not been employed operationally.

The compilation of mitigation, adaptation, and transformation activities was used to design a “stoplight” tool that can be used to evaluate, design, or communicate an FLR project. The stoplight summarizes only the actual or potential mitigation, adaptation, or transformation activities appropriate for a FLR project. It is important to emphasize that not all possible mitigation and adaptation activities will be appropriate for a given FLR project but it adds resolution to the enabling conditions and key success factors for FLR and brings the user (whether planner, evaluator, or implementer) closer to the requirements of the actual field operations of forest landscape restoration. Many complex technical problems arise following participatory planning processes, involving both governance and implementation structures and institutions; these can be highlighted using the stoplight tool.

The stoplight tool is flexible and can be used in a number of ways, depending upon the complexity of an FLR project in terms of different stakeholder objectives, ecological contexts, and the developmental stage of a project (conceptualizing, planning, prioritizing, evaluating, or communicating). The stoplight can be used in two different ways. It can be used to answer the question of where we are in terms of (i) the status of implementing an activity (current implementation level), or it can be used to answer the question of (ii) where we want to go with a certain activity (prioritization). Ideally, one would always try to answer question (i) first and from there decide on question (ii). But in some cases there may be a need to answer question (ii) without having the answers to question (i).

Given the urgency to restore deforested and degraded landscapes, combined with the immense benefits for climate change objectives that can be derived from forest and landscape restoration and taking into account the challenges faced in putting restoration into practice, a better understanding of FLR is needed. Because successful implementation of FLR depends on many motivated actors at different levels doing the right things, appropriate ways of promoting the understanding of FLR are needed including simple communication products, participatory planning, and joint evaluation of concrete landscape restoration initiatives in a given local context. In many cases, this requires a massive capacity building effort.

Chapter 1
Introduction

1.1 Land Degradation and Forest Landscape Restoration

Land degradation is a threat to global sustainability with an estimated 25 % of the world's land area already degraded (FAO 2010). Soil erosion, loss of productive potential, biodiversity loss, water shortage, and soil pollution are ongoing processes. The international community has responded to environmental degradation with several policy initiatives, such as for example the Changwon Initiative of the United Nations Convention to Combat Desertification (UNCCD) developed at the United Nations Conference on Sustainable Development Rio+20 in 2012 that aims to achieve land net degradation neutrality (LDN) by 2030 (Chasek et al., 2015). The objective of LDN is to maintain or improve the condition of land resources, including restoration of natural and semi-natural ecosystems. Similarly, the 2010 Strategic Plan of the Convention on Biological Diversity set a goal of no net biodiversity loss, and net positive impacts on biodiversity (Aiama et al., 2015; Newbold et al., 2014). Aichi Target 15 specifically calls for countries to restore at least 15 % of degraded lands by 2020.

Heightened global concerns over climate change impacts on ecosystem services such as lowered vegetation productivity, lessened mitigation capacity, and decreased water yield and quality underscore the importance of forest land cover as a carbon sink and habitat for biodiversity (Mayaux et al., 2013; Rudel, 2013). Global forest area has been reduced by approximately 50 % in historic times (Williams, 2003) with concomitant levels of carbon loss and emission into the atmosphere (Ruddiman and Ellis, 2009). Loss of forest cover has manifold impacts on climate; carbon emissions from changing land use impact on the climate system in the same way as those from fossil fuel combustion and changing albedo and reduced evapotranspiration can increase warming and alter climate circulation patterns and reduce precipitation (Boysen et al., 2014; Mahmood et al., 2014). Costanza et al. (2014) estimated cost of land use change in terms of the loss of ecosystem services from 1997 to 2011 at US $ 4.3–20.2 trillion/yr. The nexus between forests and food security is particularly important in rural areas in the tropics (Lambin and Meyfroidt, 2011; Vira et al., 2015).

Deforestation and degradation are driven by many social factors, including macroeconomic, demographic, technological, and governance (Kanninen, 2007; Lambin and Geist, 2001; Meyfroidt et al., 2010); the relative importance of drivers varies by social context. Although, under REDD+, current international focus on degradation is directed at developing countries, considerable forest areas in North America have been degraded by more intense and repeated fire (Bowman et al., 2011; Littell et al., 2009). Fire risk is increasing even without climate change. For example, the estimate in the US is that 25 million ha, mostly in the western states (Brown et al., 2004), have hazardous levels of fuel accumulation and consequently increased risk of severe wildfire.

The opportunity for restoring forests and trees in the landscape has been estimated at 2.2 billion ha of degraded land (Hooke et al., 2012; Minnemeyer et al., 2011). The international community has responded with the Bonn Challenge (http://www.bonnchallenge.org/) to begin restoring 150 million ha by 2020 and more recently the New York Declaration on Forests (UN, 2014) considerably raised the target to 350 million ha by 2030. The Bonn Challenge is an action-orientated platform established at a ministerial roundtable in September 2011 that aims to facilitate the implementation of the existing international commitments that require forest restoration as well as conservation.

Responding to this scale of needed restoration will be most effective if undertaken at the landscape level, which means integrating forests with other land uses. Integrated approaches to natural resources management have developed in various arenas over the last half century. Scherr et al. (2013) list 80 terms used by English speakers to refer to types of land and resource management that integrate food security, agriculture, ecosystem, human well-being and other values at a landscape scale, though

Restoring natural fire regimes in broadleaf forests in the Southern Appalachian Mountains, USA.
Photos © Tom Waldrop

with different 'entry points'. Climate change mitigation and adaptation is one such entry point and increasingly, it is being integrated into resource management strategies. For example, Ecosystem Based Adaptation (EbA) is the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change at local, national, regional and global levels. EbA also has multiple co-benefits for mitigation, protection of livelihoods and poverty alleviation (Munang et al., 2013). Forest landscape restoration is another such entry point.

Forest Landscape Restoration (FLR) is a challenge and an opportunity of global dimensions and understood in a broad sense, it means building the landscapes of the future (Freeman et al., 2015; Parrott and Meyer, 2012; Stanturf, 2015). It can contribute to climate change mitigation and adaptation by increasing productivity of landscapes, enhancing the resilience of forest ecosystems and landscapes, and reducing the vulnerability of forest-dependent communities. Numerous examples from around the world show that successful restoration of forest ecosystems is not only technically and economically feasible, but also socially desirable if prepared and designed with adequate participation of relevant stakeholders.

1.2 Potential Contribution to Climate Change Mitigation and Adaptation

The purpose of this report is to examine the potential contribution of FLR to climate change mitigation and adaptation and the reciprocal ways that mitigation and adaptation techniques can add value to FLR activities. As part of a collaborative project entitled "Inspire, Support, and Mobilize Forest and Landscape Restoration" between the World Resources Institute (WRI) and the International Union of Forest Research Organizations (IUFRO), funded by the German Ministry of Environment (BMU), a group of IUFRO scientists has developed a framework to demonstrate how FLR can contribute to climate change mitigation and adaptation, and to improve understanding of the relationship between FLR and climate change mitigation and adaptation. IUFRO's role in this context is to provide state-of-the-art scientific knowledge on FLR through analysis of restoration case studies, review of scientific literature and development of capacity building material. We approached the task by drawing from the scientific literature, a list of mitigation and adaptation activities relevant to FLR and developed a simple "stoplight" tool that was inspired by the diagnostic tool developed to evaluate FLR projects (IUCN and WRI, 2014). The simple stoplight framework was adopted to help decision-makers to build resilient landscapes and understand how climate objectives can be addressed through FLR. The stoplight can be used to evaluate, design, or communicate about an FLR project.

We evaluated case studies of forest restoration from around the world for their actual or potential contribution to climate change mitigation and adaptation. Case studies were assembled from projects in South and Southeast Asia, East and West Africa, Europe, Latin America and North America. In addition, we drew from the FLR literature to provide additional examples of potential mitigation and adaptation. Most of these projects were not designed as FLR in the strict sense, and climate change mitigation and adaptation was not necessarily a project objective. Notwithstanding, they provide examples of what has been done on the ground and they were chosen because there are few long-term FLR examples with adequate documentation.

This report begins with a presentation of our definitions of key terms and the concepts underlying our approach to forest landscape restoration and to climate change mitigation and adaptation (Chapter 2). Next we set out the policy context in which FLR operates, including especially the important international support mechanisms (Chapter 3). Stepping down from high-level policy, we then present the operational context for restoring landscapes (Chapter 4). This is followed by the detailed restoration activities that can promote mitigation and adaptation that comprise our stoplight tool (Chapter 5). Specific guidance on use of the stoplight tool in enhancing the understanding of FLR as a means of climate change mitigation/adaptation, FLR participatory project development and planning as well as evaluation is presented next (Chapter 6). This is based on the analysis of 15 case studies demonstrating the use of the stoplight tool in project evaluation. In a concluding section (Chapter 7), we summarise the positive aspects of and challenges faced with FLR as contribution to climate objectives and the need to promote the understanding of FLR among decision makers.

Chapter 2
Definitions and Underlying Concepts

2.1 Forest Landscape Restoration

Reducing rates of forest loss and degradation has been recognized as one key action to reduce carbon emissions while restoration has also been seen as a means of counteracting emissions through sequestration. Yet, much restoration work undertaken in the recent past has been small in scale (Melo et al., 2013; Menz et al., 2013), and often intended to restore to conditions based on reference systems (Aronson et al., 1993; Clewell and Aronson, 2006; Lamb et al., 2012). In contrast, Forest Landscape Restoration (FLR) is a long-term process both to regain ecological functionality and enhance human wellbeing. The term FLR was coined in 2000 by a group of scientists and conservation practitioners from around the world brought together by IUCN and WWF. They agreed that it was a [planned] process that aims to regain ecological integrity and enhance human well-being in a deforested or degraded forest landscape. By this definition, FLR not only broadens the scope of restoration to consideration of the entire landscape but explicitly incorporates human activities and needs.

Three key dimensions distinguish FLR from ecological restoration: its scale, its intention to restore ecological integrity (and not necessarily according to reference sites), and its emphasis on human well-being (Mansourian et al., 2005; Lamb et al., 2012). The landscape scale provides the necessary space to consider different functions, meet diverse needs, and consider trade-offs (Dudley et al., 2005; Lamb et al., 2012). Importantly, FLR is not one specific action, but indeed a process (also suggesting a temporal scale), and a vast range of actions - from local restoration actions such as enrichment planting or fencing, to international policy actions – that will all contribute to restoring the landscape (Mansourian, 2005; Stanturf, 2005; Stanturf et al., 2014b). The definition further implies that FLR is a decision-making process and not simply a series of ad hoc treatments that eventually cover large areas (Lamb et al., 2012), requiring negotiation and multi-stakeholder dialogue platforms to make the concept operational.

Landscapes are biophysical as well as social mosaics of land cover and land use, and more variable than simply "forest" and "non-forest" (Lindenmayer et al., 2008). Thus, FLR involves not only technical questions of how to restore but also considers how much and where to restore (Palik et al., 2000). Feasibility of restoration activities is determined by the ecological conditions of target sites and moreover, restoration techniques used and outcomes anticipated (Stanturf et al., 2014a) must meet the existing socio-economic conditions and fulfill the management objectives of landowners, land users, and other stakeholders including society at large (Clement and Junqueira, 2010; Shinneman et al., 2010; Shinneman et al., 2012). Advantages of the forest landscape restoration paradigm over the ecological restoration paradigm (SERI, 2004b) include the emphasis on landscape-level, as opposed to stand-level, restoration and incorporation of the human dimensions of landscape scale decision making. By virtue of its explicit inclusion of meeting human livelihood needs, FLR is more appropriate in the developing world than ecological restoration, which often has a "restore-then-preserve" underpinning (Stanturf et al., 2014b). Furthermore, FLR operates on a long timescale. Recognizing the very real long-term threats to ecosystems and ultimately to people, particularly that of climate change, signifies that FLR-related actions need to anticipate such changes and take them into consideration, particularly if restoration actions are to be sustainable.

Forest landscape restoration can contribute to climate change mitigation and adaptation by increasing productivity of landscapes, enhancing the resilience of forest ecosystems, and reducing the vulnerability of forest-dependent communities. For example, planting indigenous fruit trees can be a component of an FLR process, sequestering carbon and providing a source of vitamin-rich foods to rural communities, reducing their vulnerability to malnutrition and possibly increasing their income (Jamnadass et al., 2015). In the same way, some actions undertaken in the name of adaptation, such as protecting mangroves from fuelwood collection by supporting small community fuelwood plantations under agroforestry, can also contribute to FLR. Explicitly focusing on linkages between mitigation and adaptation, and integrating them into FLR, provides opportunities to address climate change risks while at the same time, providing sustainable flows of environmental goods and services from forests.

The terminology used for restoration is imprecise and can lead to confusion and disagreement (Stanturf et al., 2014a,b). One example is afforestation versus reforestation. For example, the IPCC (2003) says "Afforestation and reforestation both refer to establishment of trees on non-treed land. Reforestation refers to establishment of forest on land that had recent tree cover, whereas afforestation refers to land that has been without forest for much longer." Some definitions of afforestation are based on phrases such as "has not supported forest in historical time" while others refer to a specific period of years and some make reference to other processes, such as "under current climate conditions." On the one hand, the IPCC Guidelines define afforestation as the "planting of new forests on lands which, historically, have not contained forests." On the other hand, the UNFCCC sets a specific time interval of 50 years ago since it was forested. Obviously, much is left up to individual interpretation and local preferences. Rather than trying to sort through these at times conflicting definitions, we simplify the terms in this report as afforestation refers to the activity of planting trees on land that was immediately previously in another land use (e.g., row crops or pasture), whereas reforestation refers to regenerating forest land following disturbances such as logging or wildfire (Stanturf, 2005).

2.2 Climate Change Mitigation

Mitigation takes aim at the causes of climate change, the emission of greenhouse gases (GHG) and their accumulation in the atmosphere; mitigation activities relevant to forest landscape restoration are presented in detail in Chapter 5. Substituting fossil fuel intensive products with wood products is a form of offset, for example wood for steel, aluminum or concrete in construction. Additionally, wood products themselves provide

Forest landscape restoration and climate change adaptation occurs at multiple spatial scales

Figure 2.1

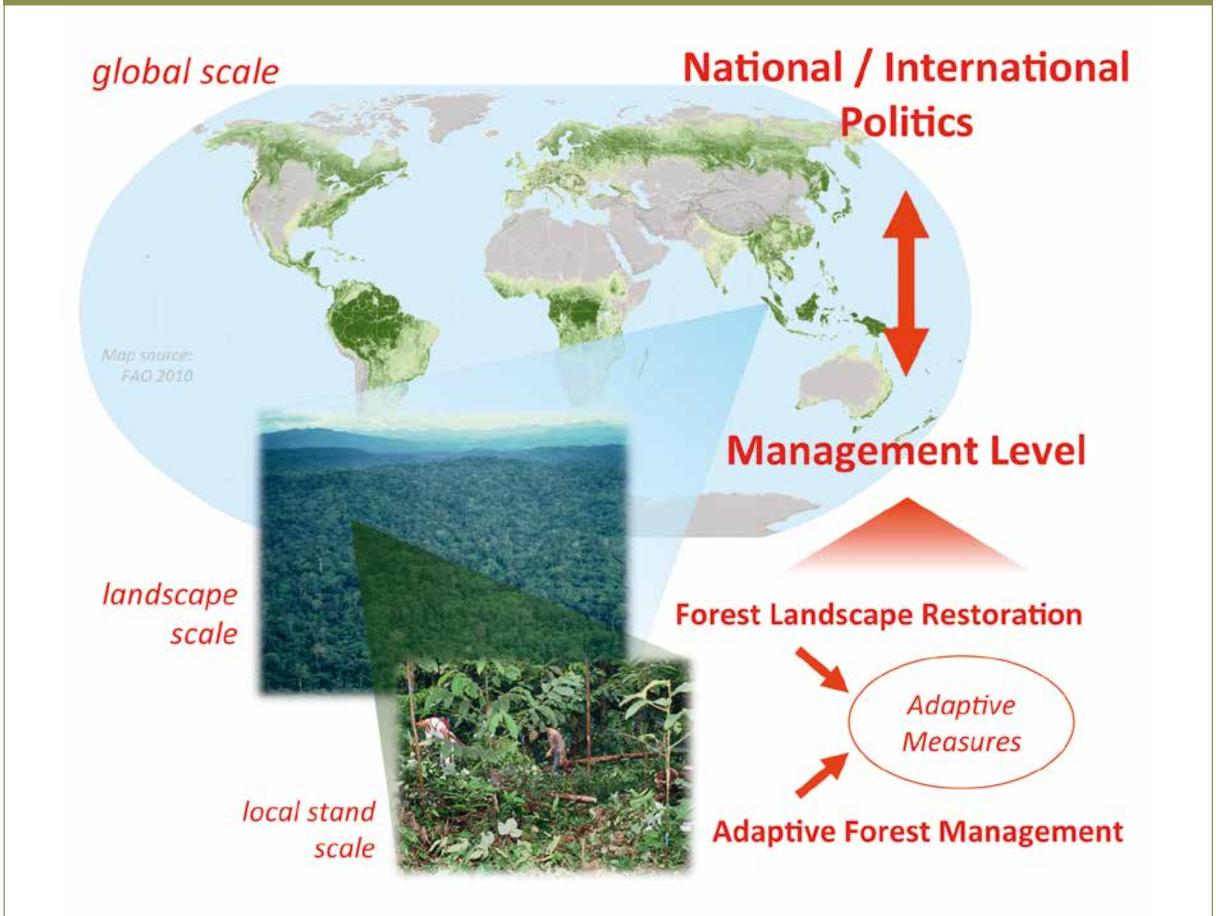


Figure based on the work of IUFRO Task Force on Forest Adaptation and Restoration under Global Change (http://www.iufro.org/science/task-forces/forest-adaptation-restoration/)

Charcoal production provides most of the residential energy used in Zambia but unsustainable methods are degrading the native miombo forest. Photos © John Stanturf

long-term storage of carbon. Mitigation interventions either reduce the sources of, or enhance the sinks for greenhouse gases (GHG) (IPCC, 2003). Carbon sequestration involves increasing forest area or the amount of carbon stocks per unit area. Activities include afforestation (conversion of non-forest areas to forest), reforestation (artificially regenerating forests after disturbance such as logging), and restoration aimed at increasing productivity and diversity of degraded forests.

Restoration can further be active or passive, with the former being achieved by planting of indigenous species, and the latter by removing pressures to enable natural regeneration to occur. Other carbon sequestration activity occurs outside of forests through some agroforestry or urban forestry activity (Ravindranath, 2007; Prabhu et al., 2015), which in terms of potential carbon sequestration may be at least of the same magnitude as forest restoration (Verchot et al., 2007; Zomer et al., 2014). These restoration activities do not occur in a vacuum, however, and social context must be considered to ensure permanence and clarify leakage. Ownership, access, and use rights to forest land are relatively straightforward in some societies but indeterminate or in flux in other societies. Studies in several countries (e.g., Ghana) clearly identified unclear tenure as one of the stumbling blocks to lasting restoration. Public and private ownership confer well-established rights to exclude or control access, supported by the coercive powers of the government (Schlager and Ostrom, 1992). Large areas of current and former forestland, however, are of what may be loosely termed mixed ownership, particularly in developing countries.

There is an increasing tendency to confer formal rights over forest lands to communities where transaction costs of settling disputes are acceptably low, and in densely populated areas of Africa land use intensification is increasingly coupled with formal recognition of individual land rights, where tree planting is a way of strengthening land rights (Holden et al., 2013b; Otsuka and Place, 2014a). Even in developed countries (e.g., Lower Mississippi Alluvial Valley, USA), there may be a clash of interests among the different stakeholders – in this case multiple federal, state, and private entities – with a stake in restoring this landscape.

Mitigation has been seen as primarily an international issue (Locatelli et al., 2011); the benefits of mitigation accrue globally, over the long-term because of the nature of the climate system. Narrowly focused mitigation actions potentially can increase the vulnerability of forests and forest-dependent communities but this can be avoided by incorporating adaptation practices into mitigation (Ravindranath, 2007). Adaptation focuses on the effects of climate change and is local in nature, with short-term effects on vulnerability of natural and social systems. Optimizing mitigation and adaptation strategies must recognize diverse ecological conditions as well as challenging governance and complex socio-cultural contexts. For the foreseeable future, the most likely mitigation and adaptation strategies in forests may focus on mitigation funded by carbon financing (Chhatre and Agrawal, 2009; Murdiyarso et al., 2012; Putz and Nasi, 2009; van Noordwijk et al., 2008) or bioenergy (Campbell et al., 2008; Lamers et al., 2014), while for agroforests, mitigation and adaptation strategies may have a wider justification for funding and direct incomes related to the relative costs and benefits of including more woody species into agricultural systems, such as shade coffee and cocoa, increasing timber production, etc. (Dawson et al., 2014a; Dewees et al., 2011).

Carbon offsets that occur in the framework of emissions trading schemes or some other public or private policy arrangement to cap greenhouse gas emissions may have a tangential role in forest landscape restoration where a livelihoods scheme substitutes wood for fossil fuels through production of biofuels or by increasing efficiency of wood processing technology or biofuels utilization (e.g., fuel efficient cook stoves or charcoal kilns). Although there have been few implemented Clean Development Mechanism (CDM) projects in forestry, there have been many projects in developing countries on efficient wood stoves. For example, cases from India demonstrate the role of fuel efficient stoves in reducing pressures on natural forests, thus enabling natural regeneration of forests, by reducing the need for large scale fuelwood collection. In this case, a national program for improved cookstoves was developed in 1985 which was then replaced by a National Biomass Cookstoves Initiative (NBCI) in 2009. Reductions in fuel consumption of 20 to 45 percent and emission reductions of 45 to 86 percent were recorded in a pilot project for Community Sized Biomass Cookstoves in 2010-11.

2.3 Climate Change Adaptation

Natural and social systems are vulnerable to climate change and adaptation is needed to maintain their functioning. Forest and community adaptation are linked: forests play a role in the adaptive capacity of local communities and the broader society by providing ecosystem services and actions of people enhance or reduce adaptability of forests by their actions (Locatelli et al., 2011). There are innate social limits to adaptation that are rooted in a society's cultural values, its ethics and belief in its traditional values in the face of fast-paced technological developments, its attitude toward risk-taking, education levels, economic status and quality of leadership (Adger, 2000). Many societies have value systems rooted in their sense of kinship to land and forests and may find technological interventions needed for adaptation that are sharply at variance with their belief systems, like creation of genetic variants for adaptation, unacceptable (Kant and Wu, 2012). But many adaptation measures likely will require significant technological leaps and it will be necessary to instill in communities confidence in the use of modern technologies through regular interactions between them and scientists in order to enhance their understanding.

Where the perception in the past has been that modern technology would be at the expense or loss of diversity, because breeding typically involves selection, which normally will reduce diversity in production populations, genomic technologies are now used to better understand the relation between the environment and the genotypes that grow there (Wheeler et al. 2015). "Landscape genomics" combine genecological, genomic and geographic information systems to infer and verify genetic variation across environmental variation (Graudal et al., 2014a; Wheeler et al., 2015), as a basis for future deployment of adapted and more diverse tree planting material to better cope with effects of climate change (Alfaro et al. 2014).

Social capital is the social and political environment that shapes social structure and enables norms to develop that shape the quality and quantity of a society's social interactions (Adler and Kwon, 2002; Grootaert and Van Bastelaer, 2001). Levels of social capital determine the adaptive capacity of a society as a whole and institutions, groups, or communities within a nation (Folke et al., 2002; Smit and Wandel, 2006). One facet of adaptive capacity is societal resilience, the capacity to buffer change, learn and develop (Folke et al., 2002; Adger, 2000). In developing countries where many restoration opportunities lie, government institutions are often weak and lack legitimacy in the countryside (Wollenberg et al., 2006). Central government agencies lack the resources and political will to enforce regulations. The local representatives of these agencies may lack even the most basic resources to be effective such as dependable transportation or fuel, tying them to their offices. Development assistance may provide short-term resources but without enhancing institutional capacity, donor projects are seldom sustainable once donor funding ends.

A typology of adaptation actions developed from activities financed by the Global Environment Facility includes the following: capacity building; management and planning; practice or behavior; policy; information; physical infrastructure; warning or observing systems; green infrastructure; financing; and technology (Biagini et al., 2014). The activities directly relevant to FLR mostly fall into the categories of practice and behavior, green infrastructure, and technology, while FLR often benefits from policy changes and improvements in national management and planning. Practice and behavior refer to revised or expanded practices that relate directly to building resilience, such as thinning stands to reduce transpiration loss as an adaptation to drought (Allen et al., 2010; D'Amato et al., 2013; Kohler et al., 2010) or by introducing genetically diverse planting material to improve adaptive capacity (Graudal et al. 2014a; Alfaro et al. 2014). Green infrastructure describes new or improved natural infrastructure that provides direct

Mangrove nursery, Pulau Dua Natural Reserve, Indonesia. Protective function of mangrove forests against coastal erosion or storm surge is invaluable and gaining even more importance in respect of climate change. Photo © Aulia Erlangga / CIFOR

Comparison of the features of incremental, anticipatory, and transformation adaptation strategies

Table 2.1

	Adaptation Strategies*		
Features	**Incremental**	**Anticipatory**	**Transformational**
Vulnerability Target	Reduce vulnerability to current stressors	Reduce vulnerability to current and future stressors	Reduce vulnerability to current and future stressors
Restoration Paradigm	Ecological restoration: historic fidelity	Functional restoration	Intervention ecology
Species	Native	Native, or exotic with functional equivalencies	Native, exotic, or designer species
Genetics	Local sources, natural evolution	Conventional breeding or biotechnology for clones or provenances with adaptive traits More deliberate management and use (deployment) of species as well as intra specific diversity	Transgenic for keystone species, cloning extinct species
Invasive Species	Prevent or remove	Accept those that are functional analogs to extirpated natives	Accept as novel
Novel Ecosystems	Prevent or avoid	Accept and manage neo-native (emergent) assemblages	Manage novel and emergent ecosystems (exotics dominate)

* Adapted from Stanturf, 2015

or indirect protection from climate hazards. An example of green infrastructure is planting coastal mangroves to adapt to rising sea levels and protect from storm surges (Alongi, 2008; Gilman et al., 2008; Zhang et al., 2012). For example, studies from Sri Lanka highlight the real value of mangroves in protecting communities from tsunamis. New or increased adoption of climate resilient technology includes improved cook stoves to reduce GHG emissions (e.g., India). Many FLR projects also include capacity building, management and planning, and information components, and may require policy revisions to be effective. Nevertheless, in most cases core activities of FLR projects involve manipulating vegetation. In Ghana, for example, local farmers in the project to rehabilitate degraded forests in the Brong Ahafo Region were trained in the production of planting materials (seedlings and vegetative propagation materials), site preparation for block planting, enrichment planting, and taungya; planting methods; methods for assessment of survival and monitoring of growth; and methods for maintaining and protecting the planted areas.

Adaptive strategies for coping with climate change may be incremental, anticipatory, or transformational (Joyce et al., 2013; Kates et al., 2012; Stanturf, 2015). Incremental adaptations are often characterized as "no-regrets" approaches where the benefits are realized under current climatic conditions, as well as providing adaptation to future conditions. That is, incremental adaptations comprised of extensions of current practices instituted to respond to variations in climate and extreme events could also reduce vulnerability or avoid loss under current conditions (Hobbs et al., 2011; Joyce et al., 2013; Kates et al., 2012). Projects that attempt to restore forests to some measure of historical fidelity or past systems (Burton and Macdonald, 2011; SERI, 2004a; Thomas et al., 2014; Tierney et al., 2009) or within a presumed range of natural variability (Agee, 2003; Keane et al., 2009) are incremental approaches (Stanturf et al., 2014a) and generally are reactive to climate change. Anticipatory approaches may use many of the same techniques as incremental approaches but with an eye toward adaptation to future climate (Alfaro et al., 2014) thereby tolerating more ecological novelty (Table 2.1). Restoration focused on resilient forests under future climate conditions aims to maintain ecological function and capacity for change, rather than specific species composition or habitat conditions for particular animals.

Transformational adaptations are attempts to proactively respond to or anticipate climate change, are larger in scale or more intense than incremental adaptations, or they are novel by their nature or new to a region or resource system (Joyce et al., 2013; Kates et al., 2012). Transformational approaches anticipate larger shifts in climate that may require significant changes to management objectives or production systems in the longer term. Transformational adaptation arises spontaneously as novel ecosystems emerge or it may be intentionally planned (Alig et al., 2004; Joyce et al., 2013). Transformational adaptations include assisted migration of species well beyond their native range (McLachlan et al., 2007; Pedlar et al., 2012; Williams and Dumroese, 2013), introduction of non-native species (Davis et al., 2011), or genetic modification to restore keystone species (Jacobs et al., 2013). Intervention ecology has been proposed as a transformational approach to restoration of degraded ecosystems (Hobbs et al., 2011; Hobbs et al., 2009; Sarr et al., 2004). Intervention ecology is based on acknowledging that the future likely will be radically different from the past, at least in many regions because the prospect is for even more rapid change under altered climate and the emergence of novel ecosystems without historic analogs (Hobbs, 2013).

Extreme drought in 2003 in southern Germany stressed many forests and was followed by beetle kill. This extreme event provided an opportunity to convert planted conifer forests to broadleaves. Photo © John Stanturf

Windows for transformational adaptation likely will be associated with extreme events, which are expected to increase in frequency and intensity under climate change (Allen et al., 2010; Cai et al., 2014; Meehl et al., 2005; Meehl et al., 2000; Reichstein et al., 2013; Rummukainen, 2012). Prolonged drought, insect outbreaks, wildfire, and wind disturbances that reach the level of a "natural disaster" (Stanturf et al., 2014b; Van Aalst, 2006), whether associated with climate change or not, all provide impetus for restoration. The window for transformative approaches likely will be narrow, as the general tendency following a severe disturbance is to restore to what was before the event (Cruz et al., 2012). Considerable planning, experimentation, and adaptive management will be required to be successful (Joyce et al., 2009), especially in advance of extreme events (Stanturf et al., 2007). A less dramatic transformational approach is the use of more genetically diverse seed sources and more systematic deployment of mixed systems and promoting assemblages of tree species that are differently adapted to climate (Prabhu et al., 2015).

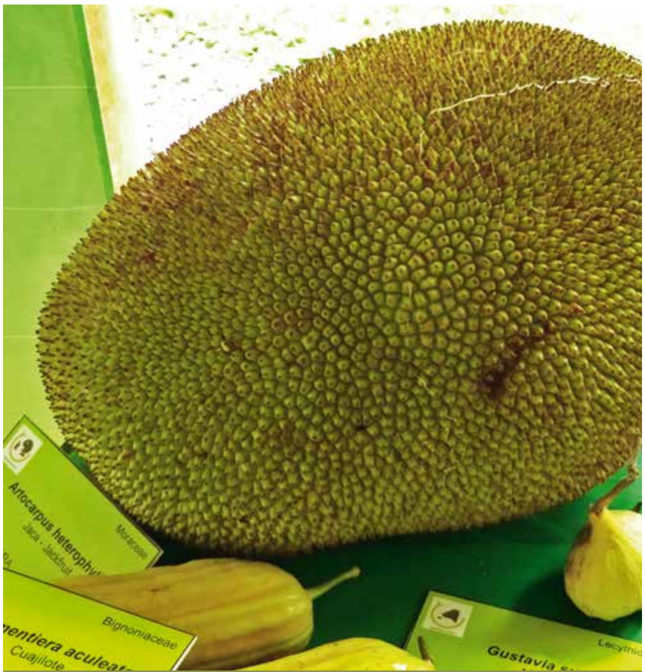
2.4 Linkages, Synergies and Trade-Offs

The linkages among mitigation, forest adaptation, and social (community) adaptation exemplify linked socio-ecological systems. Linkages between local communities and forests are diverse and complex, mirroring the diversity of forest ecosystems and socio-political arrangements. Community adaptations to climate change could affect forests positively by reducing pressures (e.g., clearing for agriculture, charcoal production, or escaped fires), improving forest management, and increasing protection by local enforcement (Gibson et al., 2005). In Ghana for example, local communities were trained in fire prevention and management, and were given fire-fighting equipment, and support in post-fire restoration efforts. Alternatively, communities might adapt to changing climate that lowered crop yields by clearing more land and increasing pressure on forests. Adapting forests to altered climate will benefit local, regional, and global communities by maintaining provisioning of ecosystem goods and services such as soil protection, provision of construction material, food etc. Local communities may benefit specifically through the roles the forest plays in food security (Pouliot and Treue, 2013; Tscharntke et al., 2012; Verburg et al., 2013; Vira et al., 2015); and meeting energy needs (Campbell et al., 2008; Zulu and Richardson, 2013). For example, in Indonesia local communities were involved in restoration inside the Gunung Halimun Salak park, using notably, fruit trees such as rambutan (*Nephelium lappaceum*), durian (*Durio sp.*), mangosteen (*Garcinia mangostana*) and nutmeg (*Myristica sp.*).

Mitigation activities such as afforestation may be situated on the landscape to improve connectivity between patches of intact forests, aiding dispersal, migration, and gene flow among populations of plants and animals. New forest areas including high-productive forests and plantations of native and/or non-native species around intact forests - especially protected areas - may act as buffers and reduce pressure on native forests as long as introduction of invasive species is avoided. Forest adaptation measures are crucial to ensuring permanence of carbon fixed in forests established for mitigation purposes (Galik and Jackson, 2009; Hurteau et al., 2008) and may increase carbon sequestration in native forests through improved forest management. Similarly, community adaptation activity such as conservation agriculture that increases crop yields may benefit carbon permanence in mitigation forests by reducing the need to expand cropped land to maintain sufficient food and in the process, increase carbon sequestered in cropland soil. Mitigation forests may provide ecosystem services to communities as well as carbon payments under CDM or REDD and the afforestation program may provide local jobs in nurseries, planting, and tending the restoring forest. For example, in Lake Victoria smallholder farmers have been trained in agroforestry techniques which contribute to carbon sequestration and as an incentive, they have been given free seeds and seedlings. Bioenergy plantations established on depleted cropland may provide income to landowners as well as creating jobs to establish, tend, and process the crop (Campbell et al., 2008).

The greatest opportunities for incremental adaptation exist where active forest management already occurs (Guldin, 2013; Spittlehouse and Stewart, 2004). Establishing new forests or restoring degraded forests must balance sustainability under current climate conditions and adaptability to future climates, thus choice of species, seed source, stand structure, and management regime may require trade-offs. Stand-level adaptation will be influenced by landscape position and site characteristics; existing forest conditions may narrow alternatives (Kolström et al., 2011; Stanturf, 2015). In general, striving for quick site capture (Pichancourt et al., 2014; Stanturf et al., 2001) will maximize carbon benefits and avoid invasion by grasses and herbaceous species that could increase fire risk (D'Antonio and Vitousek, 1992). Other mitigation activities include favoring multiple species over single species plantings at the stand level (Gamfeldt et al., 2013; Hulvey et al., 2013a; Kelty, 2006; Lockhart et al., 2006; Lockhart et al., 2008) and developing structure/age diversity at the landscape level (Millar et al., 2007; Oliver et al., 2012). Landscape level restoration in Brazil's Atlantic forest is an example of such large-scale and diverse restoration actions. In this case, they include policy-level actions – a new Forest Code (Law # 12651/2012) passed in 2012, to restore six million hectares – with on the ground actions such as the reintroduction of native species by seedling planting or the removal of ecological barriers to support the establishment of new species through seed dispersal from neighboring forests.

Extreme events such as natural disasters can create a window of opportunity for transformative activity (Pelling and Dill, 2010; Young, 2010), temporarily lowering institutional and social barriers to change, allowing for "directed transformation" by institutions (Nelson et al., 2007). For example, after the 2009 "Black Saturday" megafire in Victoria state, Australia (Cruz et al., 2012), O'Neill and Handmer (2012) proposed four areas for transforming bushfire risk: reducing hazardous fuels, lowering exposure of infrastructure and buildings, reducing vulnerability of the population, and increasing adaptive capacity of institutions. They acknowledge the difficulty of transformative adaptation and note the vigorous resistance from the public to specific recommendations made by a royal commission that were designed to minimize the risk of a similar megafire occurrence (O'Neill and Handmer, 2012).



Restoring native fruit trees, such as Jackfruit *(Artocarpus heterophyllus)* in rural areas of SE Asia can help improve food security of local communities. Photo © Michael Kleine

Absent such compelling reasons to adapt as a hurricane, tsunami, or a megafire; the practical difficulties and institutional obstacles may be even greater. Large-scale harvesting on public land to convert to other species better adapted to uncertain future climate likely would face opposition from traditional users and the public at large, as well as lack of funds to underwrite the effort, especially on non-production and conservation forests. For example, Guldin (2013) speculated on the financial hurdle of changing species composition of forests in the southern US, based on the experience of developing intensive pine management by conversion from naturally regenerated stands. A century-long effort was made to convert 25 million ha, a fourth of the forest area, into commercial plantations. The scale of the effort was substantial: operational costs of approximately $US16 billion were expended on private land (Guldin, 2013) - notwithstanding the millions invested in research and development by public and private entities (Stanturf et al., 2003a; Stanturf et al., 2003b). The undertaking was made with reasonable risk and the guarantee of a continuous supply of wood and fiber; the resulting forest estate has made the South the most productive forest region in the US (Stanturf et al., 2003b).

Chapter 3
Policy Context

At the Earth Summit held in Rio de Janeiro in 1992, three so-called Rio conventions were drawn up: the convention to combat desertification (UNCCD), that on climate change (UNFCCC), and that to protect biodiversity (CBD). They form the cornerstones of international and national environmental and forest policies. Forest landscape restoration (FLR), and policies related to biodiversity, desertification control, and climate are closely interlinked: on the one hand, FLR can contribute to meeting commitments under the Rio conventions and on the other, international laws, tools, and funds that these conventions generate can accelerate implementation of FLR (see examples in Box 3.1).

In addition, the Forest Principles encapsulating the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests, also signed at the same event, provide the basic framework for sustainable forest management policies across the world.

In this section, the focus is on the links between FLR and the Rio Conventions, as well as other major international policy initiatives and global support programs.

3.1. The Rio Conventions and FLR

The three Rio Conventions (i.e., UNFCCC, UNCCD, and CBD) have evolved since their creation in 1992 with two important developments of relevance to FLR:

- Recognition of the increasing role of restoration; and
- Commitment to working more closely together, notably on climate change.

These developments provide a clear opportunity for integrated work on FLR and climate change mitigation and adaptation.

Negotiations at UNFCCC COP in Bali 2007, where the concept of reducing emissions from deforestation and forest degradation was discussed. Photo © Jan Golinski / UNFCCC

3.1.1 UNFCCC

At the 2007 Bali Conference of the UNFCCC a very significant decision to stimulate action for reducing emissions from deforestation in developing countries was taken recognizing the critical role of deforestation and forest degradation, and conversely, of forest restoration, in climate change mitigation. Since then it has evolved into "Reducing emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests and enhancement of forest carbon stocks" commonly abbreviated as REDD+. REDD+ programs can be at national or large sub-national scale and developed countries are increasingly committing themselves to financing REDD+ activities in the developing world even as the developing countries themselves are proposing to bring larger extents of deforested lands, degraded forests, and other lands under REDD+. Finance remains a major hurdle for REDD+ and there have been few individual developed country commitments to REDD+ in INDCs. It is not actually clear that there will be an exchange of carbon benefits.

Salinized Landscape in Western Australia. Salinization was caused by conversion of the native Eucalyptus forest to wheat farming. Restoration by phase farming, where wheat is rotated with Eucalyptus (mallee), attempts to draw down the water table and flush salts from the soil. Carbon credits were to be gained from the restoration as a way to offset costs. Photos © John Stanturf

The National Adaptation Programs of Action (NAPAs) have been created for the specific purpose of dealing with the immediate climate change adaptation needs of Least Developed Countries (LDC). In keeping with their objective of providing urgent assistance, NAPAs are country-driven and action-oriented plans prepared without conducting new research. Instead, they use a synthesis of available information and a participatory assessment of vulnerability to the existing climate variability and to extreme climate events that have occurred in the country in recent years, set priorities for action, and identify key adaptation measures. The UNFCCC has laid down guidelines for NAPAs and also set up an LDC Expert Group to provide advice on the preparation and implementation strategies for NAPAs. As of 2013, 48 LDCs had submitted their NAPAs to the UNFCCC and almost all of these include forest-related measures among their adaptation priorities (UNFCCC, 2015a).

The Nationally Appropriate Mitigation Actions (NAMAs) include mitigation actions aligned to the national development goals that have the potential to cause significant reduction in emissions of greenhouse gases, and enhancement of carbon sinks in forests, trees, and soils in developing countries by the year 2020 relative to 'business-as-usual'. The NAMAs at the national level are submitted by the national governments to the UNFCCC with the objective of receiving financial and technological support, and unlike NAPAs, the opportunity to submit proposals for NAMAs is available to all developing countries and not merely LDCs.

In addition to national level NAMAs, other public and private institutions - including commercial organizations - can also submit NAMAs to the UNFCCC NAMA Registry and seek technological and financial support. These submissions can be project-based mitigation actions, or larger sectorial or geographically based programs. Implementation of these NAMAs can, however, begin only with the approval of the national government (UNFCCC, 2015b).

In preparation for a new international climate agreement, to be finalized at the UNFCCC Conference of Parties (COP 21) in Paris in December 2015, countries have agreed to outline publicly the post-2020 climate actions they intend to take under a new agreement. Developed and developing countries are currently submitting their national post-2020 climate action commitments, known as Intended Nationally Determined Contributions (INDCs). These commitments will form the foundation of the 2015 climate agreement. WRI and UNDP have prepared draft guidance on what to include in an INDC that focuses on estimating emissions and mitigation activities (WRI, 2015). Even though the parties have agreed that mitigation reporting is required in an INDC, countries can also decide to include adaptation activities (van Asselt et al., 2015).

3.1.2 UNCCD

Desertification, along with climate change and the loss of biodiversity, was identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. Established in 1994, UNCCD is the sole legally binding international agreement linking environment and development to sustainable land management. The convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found. In the 10-year strategy of the UNCCD (2008-2018) that was adopted in 2007, Parties to the Convention further specified their goals to include forging a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in affected areas, in order to help reduce poverty and support environmental sustainability. The UNCCD promotes on the one hand the prevention of land and forest degradation through sustainable land and forest management practices and on the other, the restoration of already degraded land and forests.

3.1.3 CBD

In the 1992 Convention on Biological Diversity (CBD) contracting parties commit to "rehabilitate and restore degraded ecosystems, and promote the recovery of threatened species" (art. 8 (f)). In 2010, at the tenth CBD Conference of the Parties (COP) in Nagoya, the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets were agreed. Specifically, Aichi Target 15, calls for the "restoration of at least 15 per cent of degraded ecosystems" which links directly with FLR (although it is not only about forests).

Further, at the CBD COP in 2012, the Hyderabad Call for a Concerted Effort on Ecosystem Restoration was launched by the Governments of India, South Korea and South Africa as the hosts of the CBD, UNCCD and UNFCCC respectively in that year along with the Secretariat of the Ramsar Convention, UNEP and a few other international organizations. The call highlights that a stage has been reached where conservation by itself is insufficient to prevent the loss of biodiversity and ecosystem services and that massive coordinated public and private efforts are required, including by businesses, to support, finance, facilitate and implement the rehabilitation of degraded lands and restore ecosystems.

3.2 Global Policy Initiatives on Forest Landscape Restoration

Beyond the official UNFCCC, UNCCD and CBD agendas, two FLR-related initiatives in particular have served to promote FLR at the highest political levels, namely the Bonn Challenge on Forest Landscape Restoration and the New York Declaration on Forests.

3.2.1 Bonn Challenge

At the invitation of the German Government and IUCN, the Bonn Challenge was established at a ministerial roundtable in September 2011, calling for the restoration of 150 million hectares of deforested and degraded lands by 2020. This challenge seeks to actively engage states helping them achieve progress on their existing international commitments under the CBD Aichi Target 15, UNFCCC REDD+ goal and the Rio+20 land degradation target, all intended to lead to carbon richer landscapes that are bio-diverse, economically more productive, and resilient against climatic vulnerabilities. To-date a total of 59.58 million hectares has been committed under the Bonn Challenge for restoration (GPFLR, 2015).

3.2.2 New York Declaration on Forests

The New York Declaration on Forests is a non-legally binding political declaration agreed to by a large number of heads of governments and international institutions, business leaders and heads of civil society, endorsing a global timeline to cut natural forest loss in half by 2020, and work towards bringing it to no loss by 2030. It aims at restoring 150 million hectares of degraded landscapes and forestlands by 2020 and includes the restoration of an additional 200 million ha of forests and croplands by 2030. The commitments made include new bilateral and multilateral financing programs for reduced deforestation over the next six years and new forest commodity procurement policies by some of the largest importers of these goods (UN, 2014). According to UN-REDD, achieving the intended outcomes of the New York Declaration could potentially reduce emissions by 4.5–8.8 billion tons per year by 2030 (UN-REDD, 2015). The Declaration is based on a shared vision of slowing, halting, and reversing global forest loss while simultaneously enhancing food security for all.

3.3 Forest Landscape Restoration Support Mechanisms

Specific support programs in terms of awareness raising, broadening of political support, and mobilizing financial resources have been created in order to promote and support FLR. These include the Global Partnership on Forest and Landscape Restoration, the FAO Forest and Landscape Restoration Mechanism, and the Forest Ecosystem Restoration Initiative.

3.3.1 Global Partnership on Forest and Landscape Restoration (GPFLR)

The Global Partnership on Forest and Landscape Restoration (GPFLR) is a worldwide network of FLR practitioners and supporters working from grassroots level upwards to spread best practice and political awareness of restoration and its benefits. It is coordinated by a secretariat hosted at IUCN. The Global Partnership on Forest and Landscape Restoration builds support for restoration with decision-makers and opinion-formers at both local and international levels, and influences legal, political and institutional frameworks to support FLR. It is a voluntary network of governments, international and non-governmental organizations and others seeking to facilitate exchange and learning, generate new knowledge and tools, and act as a vehicle to mobilize capacity and expert support to address the practicalities of forest landscape restoration. Several learning sites (GPFLR, 2015b) have been identified within the Global Partnership that showcases a variety of geographical areas, stakeholder groups, socio-economic conditions, and restoration strategies.

3.3.2 FAO Forest and Landscape Restoration Mechanism

At the 22nd Committee on Forests in 2014, the United Nations Food and Agriculture Organisation (FAO) proposed the establishment of the Forest and Landscape Restoration Mechanism (FLR Mechanism), to help countries to achieve their commitments towards the Bonn Challenge and the Aichi Targets, catalysing the work of FAO in close collaboration with key partners in the context of the Global Partnership on Forest and Landscape Restoration (FAO, 2015). Its initial phase spans a seven-year period from 2014 to 2020. The FLR Mechanism is intended to support the implementation, monitoring, and reporting of FLR both at the country level and globally. At the national level, it will notably facilitate a multi-stakeholder process in selected countries to define needs and opportunities for FLR; develop, compile and disseminate tools and best practices related to FLR; support the establishment of pilot projects and help broker new large-scale projects and programs with national, bilateral and multilateral donors and the private sector; and support adequate quality control of well-established FLR efforts, to ensure compliance with accepted guidelines, norms, and standards.

The FLR Mechanism will work closely and in full complementarity with other FAO-hosted arrangements and programs that have been set up to support related objectives, such as the UN-REDD program, the Forest and Farm Facility (FFF), the Mountain Partnership Secretariat, the Globally Important Agricultural Heritage System (GIAHS) initiative, the Land Degradation Assessment in Drylands (LADA) program, the World Overview of Conservation Approaches and Technologies (WOCAT), the State of the Worlds Forest Genetic Resources (FAO 2014a) and its associated Global Plan of Action (FAO 2014b; Loo et al., 2014), and others.

3.3.3 Forest Ecosystem Restoration Initiative (FERI)

In 2014, at the 12th Conference of the Parties (COP) to the Convention on Biological Diversity, the Korea Forest Service, in cooperation with the Executive Secretary, the FAO and other partners, launched the Forest Ecosystem Restoration Initiative (FERI) to support ecosystem restoration activities (CBD, 2015). The FERI is intended to support Parties to the Convention on Biological Diversity in achieving Aichi Biodiversity Targets 5, 11 and 15 in an integrated manner. In particular, it directly supports developing country Parties as they operationalize national targets and plans for ecosystem conservation and restoration integrated into updated National Biodiversity Strategies and Action Plans. FERI is a six-year initiative with four interrelated components:

- Capacity-building (workshops, learning exchanges at regional and sub-regional levels and technical clinics);
- Implementation support (assessments of degradation and restoration potential and funding to leverage funds from other sources for restoration activities);
- Technical support and cooperation (international/global technical support networks, regional support hubs/“centres of excellence”); and
- Meetings of experts and scientific groups on issues related to forest ecosystem restoration.

Community consultations on forest landscape restoration in Ghana. Restoration projects strongly depend on capacity building, planning and information components.
Photo © Ernest Foli

3.3.4 Forest Landscape Restoration Funding Mechanisms

Several investment entry point and triggers for an integrated landscape approach could include FLR (Shames et al., 2014), including biodiversity conservation, production, and economic development. A useful distinction is between asset investments and enabling investments (Elson, 2012). Asset investments build on enabling investments, which lay the institutional and policy foundations for integrated landscape management, to create tangible value that is returned back to the investor or land manager, ideally with a profit.

With growing global interest in FLR, it is anticipated that more such mechanisms will arise. A number of global funding mechanisms exist which could support both FLR and its role in mitigation and adaptation. A selection of such funding mechanisms is presented in Box 3.1.

3.4 Setting the Stage

Reducing emissions from deforestation and increasing forest restoration will be extremely important in limiting global warming to 2°C. Forests represent one of the largest, most cost-effective climate solutions available today (Parrotta et al., 2012). Action to conserve, sustainably manage, and restore forests can contribute to economic growth, poverty alleviation, rule of law, food security, climate resilience, and biodiversity conservation. It can help secure respect for the rights of forest dependent indigenous peoples, while promoting their participation and that of local communities in decision-making.

Forest landscape restoration and climate-related policy are closely inter-linked: on the one hand, FLR can support achievement of climate-related commitments and on the other climate policies, tools and funds can accelerate implementation of FLR. As briefly outlined in this section, existing global conventions, FLR policy initiatives, and support mechanisms clearly provide a comprehensive framework for action.

Fostering closer collaboration between the conventions around FLR with the aim to promote climate mitigation

Box 3.1

A Selection of Global Funding Mechanism

Green Climate Fund

The Green Climate Fund (GCF), established in 2010, is a financial mechanism to promote low-emission and climate resilient development in eligible developing countries. Stakeholders are 194 sovereign states which are signatories to the UNFCCC. As of 10 April 2015, 33 governments had pledged USD 10.2 billion to the GCF, including eight developing countries. The Fund provides support to developing countries to limit or reduce their greenhouse gas emissions and to adapt to the impacts of climate change, taking into account the needs of those countries particularly vulnerable to the adverse effects of climate change.

Forest Investment Program (FIP)

The USD 785 million Forest Investment Program (FIP), part of the USD 8.1 billion Climate Investment Fund (CIF), supports developing countries' efforts to reduce emissions from deforestation and forest degradation and promote sustainable forest management and enhancement of forest carbon stocks (REDD+). The FIP is active in eight pilot countries. Unique to the FIP is the USD 50 million "Dedicated Grant Mechanism for Indigenous Peoples and Local Communities (DGM)." It is the largest global REDD+ initiative created solely for and by indigenous peoples and local communities. The first DGM project is in Brazil, where USD 6.5 million was approved to help finance agroforestry initiatives based on native and adapted fruits in the Cerrado region.

Investment Fund for Land Degradation Neutrality (LDN Fund)

The LDN Fund is a public – private partnership (PPP) between private institutional investors, international finance institutions and donors. Its goal is to support the transition to land degradation neutrality (LDN) by rehabilitating and restoring land while generating revenues for investors from sustainable production on rehabilitated land.

The Global Environment Facility (GEF)

At its sixth replenishment (for the period July 2014 to June 2018), the GEF allocated USD 431 million to the land degradation focal area. In addition within the GEF, specific funds such as the Least-Developed Countries Fund (LDCF), the Adaptation Fund and the Special Climate Change Fund (SCCF) provide funding for climate adaptation.

and adaptation can provide an effective means of accelerating national policy alignment and action not only for restoration and climate action, but also to achieve joint work under all three conventions. Indeed, FLR provides opportunities for synergies at various levels: among the conventions, on forest-related work, on climate-related work and for Parties to optimise their work to meet commitments under several conventions.

While there is growing enthusiasm for FLR, with numerous countries committing to the Bonn Challenge, at present there is no agreement on how to validate the commitments or to monitor the effectiveness of restoration activity. Without agreed upon standards for what constitutes FLR on the ground, there is a risk that the Bonn Challenge could be seen by some observers as a form of greenwash.

Rural scenery in Costa Rica. Appropriate distribution of forests, trees and agricultural crops contributes to climate objectives, productivity and several other social benefits. Photo © Michael Kleine

However, with clear guidance, support and effective monitoring, these commitments would not only help move towards objectives of the several Conventions but also contribute to livelihood security by restoring ecosystem goods and services, and reducing disaster risks. In this respect, the role of technology, monitoring, and the establishment of clear standards, guidelines, and methodologies, will be important. At the same time, country specificities need to be acknowledged and this requires adequate flexibility that does not compromise integrity of efforts.

International conventions and facilitation processes can provide the right external environment for forest landscape restoration but these would amount to little unless national policies and governance systems enable good quality planning and implementation of FLR, creating employment, incomes and other incentives for communities to involve themselves in the efforts. It is striking to see how far the international policy framework has developed and continues to develop; but how little FLR has been implemented in practice, in particular in developing countries (with some notable exceptions) where the potential is greatest. Most focus to date has been on governance structures with the implicit assumption that the technical challenges would be easier to overcome. However, this is rarely the case. Institutions to guide and implement are often weak and their technical and operational capacity limited (FAO 2014a; Graudal et al. 2014a). Furthermore, in many cases the weakest and most vulnerable sections of the society would have to be kept at the center to obtain lasting results. Without such conditions, the success of FLR would only be superficial at best, planting trees that barely survive, contributing little to the local economy, and even less to the ecosystem.

Chapter 4
Operational Context for Landscape Restoration

Reality on the ground differs from country to country and what works in one place may not work in another: restoration strategies should be adapted to fit local social, economic, and ecological contexts (Clement and Junqueira, 2010; Menz et al., 2013). Of the estimated 2.2 billion hectares of degraded land that presents an opportunity for forest landscape restoration (Minnemeyer et al., 2011), the greatest potential exists in mosaic landscapes (Figure 4.1) in the tropics and temperate zones, that is in areas of moderate human occupation (between 10 and 100 people per km^2). In the tropics, where biodiversity and the potential for mosaic restoration are high (Bellard et al., 2014; Dirzo et al., 2014; Visconti et al., 2015), rural populations are generally vulnerable to climate change and susceptible to food insecurity (Dixon et al., 2003; McMichael et al., 2006; Patz et al., 2005; Thornton et al., 2014). In mosaic landscapes, multiple and frequently unclear land ownership and land tenure arrangements will complicate attempts at forest landscape restoration (Mansourian and Vallauri, 2014). Many landowners in a landscape will mean many different objectives and many possibilities to implement restoration; achieving consensus on restoration objectives will require collaborative and participative approaches (Lamb et al., 2012; Mercer, 2004). On the one hand, where tenure is insecure or vague, landholders may lack the will or the ability to invest in long-term improvements (Hayes et al., 1997; Otsuka and Place, 2014b; Robinson et al., 2014). On the other hand, granting secure tenure can provide incentive to clear land, without appropriate legislation and compensation to retain or restore forests for wider benefits.

Even though there is no "one size fits all" approach to FLR, there are commonalities in the factors necessary for achieving synergies in mitigation and adaptation in FLR, including supportive policies and strategies, programs and projects, and institutional and financial arrangements (Duguma et al., 2014; Mansourian and Vallauri, 2014). Suding et al. (2015) proposed four broad principles in planning restoration: it should aim at enhancing ecological integrity, actively associate and benefit society, have the potential of becoming self-sustaining over a period of time, and should take into account the past ecosystem history of the land and the people and their expectations from the forest lands to be restored over the near and extended future. The current ecological status and the specific restoration objectives would then decide the degree to which each of these basic principles would drive the restoration process. Similarly, the guiding principles for ecosystem-based adaptation promote resilient ecosystems and maintaining ecosystem services (Travers et al., 2012). More detailed success factors for FLR can be found in the Rapid Restoration Diagnostic Tool produced by the World Resources Institute (IUCN and WRI, 2014).

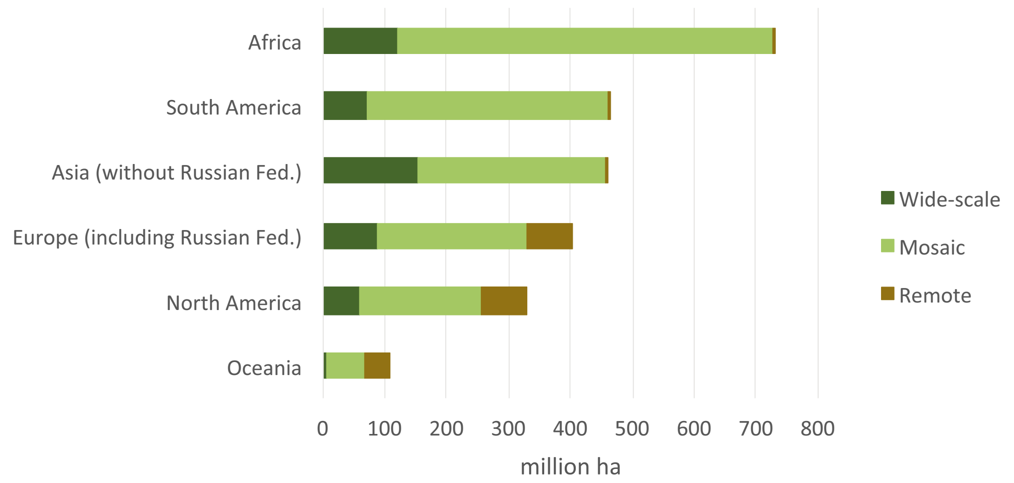
An estimated 2.2 billion ha globally of deforested and degraded land presents opportunities for remote restoration (in unpopulated areas where density <1 person km^2 within a 500 km radius), wide-scale restoration (in areas with <10 people km^2 and with the potential to support closed forest) and in mosaic landscapes with moderate human pressure (between 10 and 100 people km^2) (Source: Minnemeyer et al., 2011; Laestadius et al., 2012).

Successful landscape restoration depends on a large number of coinciding conditions. From an operational point of view it may be useful to develop a typology of objectives for forest landscape restoration (Mansourian and Vallauri, 2014). Here we focus on some key success factors for FLR that enhance the potential to contribute to climate change mitigation and adaptation, namely securing multifunctional landscapes, supportive policies and strategies, and enabling conditions (some prominent success factors for forest landscape restoration identified in the literature are summarized in Table 4.1).

4.1 Multifunctional Landscapes

Multifunctional landscapes that provide ecological, economic, and social benefits are the goal of forest landscape restoration (Lamb et al., 2012; Mansourian et al., 2005). Undertaking restoration requires a suite of technological, silvicultural, political, economic, and social strategies to

Global Forest Landscape Restoration Opportunities Figure 4.1



An estimated 2.2 billion ha globally of deforested and degraded land presents opportunities for remote restoration (in unpopulated areas where density <1 person km^2 within a 500 km radius), wide-scale restoration (in areas with <10 people km^2 and with the potential to support closed forest) and in mosaic landscapes with moderate human pressure (between 10 and 100 people km^2) (Source: Minnemeyer et al., 2011; Laestadius et al., 2012)

enhance the economic and ecological returns, the ease of acceptance, and the sustainability of the process. A focus on landscapes, as opposed to individual sites, typically entails balancing a mosaic of interdependent land uses across the landscape (Lamb et al., 2012; Lindenmayer et al., 2008; Sayer et al., 2013), such as protected forest areas, ecological corridors, regenerating forests, agroforestry systems, agriculture, well-managed plantations, and riparian strips to protect waterways. A long time delay in the delivery of results can de-motivate communities, thus effectively increasing tree cover across the landscape should generate a suite of ecosystem goods and services over time, with some appearing in the short term.

Appropriate tree cover is determined notably, by local ecological and site conditions, species traits (including intraspecific variation), and landowner objectives. In some places, trees may be added to agricultural lands without forming a closed forest canopy, in order to enhance food production, reduce erosion, provide shade, and produce firewood. In other places, trees may be added to create a closed canopy forest capable of sequestering large amounts of carbon, protecting downstream water supplies, and providing rich wildlife habitat. Trade-offs may be necessary, such as between maximum carbon sequestration and landowner expectations for productivity of commercial species or enhancement of biodiversity. Not all landscape elements require closed canopy forests; agroforestry and trees on farms can meet mitigation objectives and landholder food security needs. Some areas within the otherwise forested landscape may not require trees at all, such as native grasslands (Veldman et al., 2015). In any event, in line with the objectives of FLR, native forests should not be converted to commercial plantations, whether for timber or food crops (IUCN and WRI, 2014), and biodiversity should not be damaged in undertaking forest restoration.

4.1.1 Ecological Functions

Landscape restoration may be undertaken in many ways, for multiple objectives (Stanturf et al., 2014a; Stanturf et al., 2014b; Mansourian and Vallauri, 2014). A given landscape may present an opportunity for wide-scale forest restoration, mosaic restoration, or remote restoration (IUCN and WRI, 2014; Minnemeyer et al., 2011) where the differentiating factor is the density of the human population. Wide-scale restoration to create contiguous, closed canopy forest is most suited for areas with low population density (Figure 4.1) and the presence of one or a few landowners (particularly public land) facilitates decision-making on where and how to restore. Remote restoration refers to forests more than 500 km from settlements that have been degraded by pests or wildfires. Boreal forests comprise the greatest opportunities for remote restoration, likely through a combination of active and passive means (IUCN and WRI, 2014; Minnemeyer et al., 2011; Stanturf, 2015). Mosaic restoration aims to create a mix of multifunctional land uses including forests and trees outside of forests (i.e., woodlands, savanna, and agroforests). Other options for a landscape include trees on farms (i.e., agroforestry) and areas devoted to food production (Meyfroidt et al., 2010; Smith et al., 2010). There is an opportunity for an estimated 1 billion hectares of agroforestry to provide mitigation and adaptation benefits (Zomer et al., 2014).

Restoring ecological functionality includes promoting resilient ecosystems (Travers et al., 2012) with ecological integrity and the ability to eventually become self-sustaining (Suding et al., 2015). Resilient ecosystems are able "to absorb disturbances and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"

(Holling, 1973). Operationally, resilience must be defined in terms of desired future conditions following disturbance (DeRose and Long, 2014) including climate change. Thus, restoring resilient forest landscapes means restoring a landscape of forest stands with the variation in structures and compositions that will continue to provide desired ecosystem services under current and future climates (Travers et al., 2012).

4.1.2 Economic Functions

A restoration project is more likely to be successful if it yields overall net positive financial impact for landowners and/or net positive economic impact in public benefits relative to the *status quo* land use (Travers et al., 2012). Benefits may derive from diversification or new marketable products from the restored forest that provides incentive to maintain forest cover in the face of competing land uses (Suding et al., 2015; Travers et al., 2012). Timber and non-timber forest products (e.g., firewood, charcoal, fruit, mushrooms, roots, honey, and medicinal plants) are important commodities to be sold or traded, as well as consumed (Dawson et al., 2014a). Forest products are used as coping mechanisms, such as "famine foods" when crops fail (Dewees, 2013; Shackleton, 2014; Vira et al., 2015) and as adaptive strategies, anticipating stresses such as climate variability (Alfaro et al., 2014; Graudel et al., 2014; Pramova et al., 2012). The short-term costs of restoration are frequently perceived to outweigh the benefits (which may be longer-term). Costs also include the opportunity cost of not using the land or forest for other purposes. For this reason, less costly options (such as passive or assisted natural regeneration) are frequently preferred. Equally, in many developing countries, funding for large-scale restoration is more likely to come from external sources via special funds or development aid. Payments for ecosystem services would greatly help in expanding and expediting restoration but this concept is still in its infancy and much remains to be done to make it economically workable (Fisher et al., 2009; Wunder et al., 2008; Wunder, 2015).

Representing one of the smallest forest landscape elements, trees on farms can already meet significant carbon mitigation objectives, besides many other ecological, economic and social functions – including as fence posts in Costa Rica. Photo © Michael Kleine

4.1.3 Social Functions

Social benefits stem from the flow of forest goods and services restored in a landscape. Rural communities are the most affected by degraded landscapes as they are the most vulnerable and closest to the resource. Locally, benefits should be provided directly to communities with a historical or cultural connection to forests (e.g., forest-based traditions and cultural heritage, forest-based livelihoods and employment), taking into account the history of the landscape, the ways that local people have used the natural resources present, and their expectations for the continued access to resources (Suding et al., 2015). Thus, in line with its definition of improving human wellbeing, an FLR project should not displace local people or alienate them from traditional access to resources without free prior and informed consent and probably, acceptable forms of compensation (IUCN and WRI, 2014).

Indirect economic benefits accrue through the provision of ecosystem services notably by avoiding natural hazards such as soil erosion, landslides, coastal erosion or storm surge, and flooding (Van Aalst, 2006) that may increase from higher frequency of extreme events under future climate (Cai et al., 2014; Kunkel et al., 2013). The role of forests and deforestation in watershed regulation lacks certainty (Pramova et al., 2012) despite a large literature on the hydrologic functions of forested watersheds. Surface erosion is a natural process that is accelerated by soil disturbance and compaction from management activities including land clearing and cultivation, especially on steep slopes (Sidle et al., 2006; Valentin et al., 2008). Mass movement including shallow landslides can be triggered by rainfall events; deep rooted trees and shrubs provide cohesive strength and thereby may reduce the probability of landslides (Bruijnzeel, 2004; Sidle et al., 2006). It should be noted that roads typically contribute more to landslides and surface erosion than other land uses by orders of magnitude (Sidle et al., 2006).

Downstream communities are affected by land management in upland watersheds when deforestation and other soil disturbing management practices contribute to storm flow and floods (Pramova et al., 2012). The evidence for forests reducing floods has been questioned (Bruijnzeel, 2004); although forests may have little impact on reducing flooding from large rainfall events, they may prevent frequent and smaller floods (Locatelli and Vignola, 2009; Pramova et al., 2012).

Coastal systems are high-energy environments (Stansby, 2013) and coastal forests such as mangroves provide protective functions (Burbridge, 2012). Similar to the uncertainty of upland forest protective functions, the evidence for the protective functions of coastal forests is largely descriptive and anecdotal (Pramova et al., 2012). Nevertheless, studies from Sri Lanka show that areas protected by mangroves suffered much lower human loss of life during the devastating tsunami of 2005. Adaptive restoration efforts need to be based on a good understanding of an area's coastal dynamics and the ecosystem characteristics such as geomorphology and risk of extreme events that determine vulnerability (Alongi, 2008; Gilman et al., 2008). Coastal forests provide other benefits, such as stabilizing erosion caused by sea-level rise and tidal flooding (Alongi, 2008; Pramova et al., 2012; Thampanya et al., 2006).

Table 4.1

Prominent success factors for forest landscape restoration identified in the literature

Success Factors		
Factors	**Features**	**Reference**
Multifunctional		
Ecological	Promote resilient ecosystems	Travers et al., 2012
	Restore ecological integrity	Suding et al., 2015
	Become self-sustaining	Suding et al., 2015
	Maintain ecosystem services	Travers et al., 2012
Economic	Diversification, avoided damages, new marketable products	IUCN and WRI, 2014; Suding et al., 2015
	Net positive financial impact (private benefits) and/or net positive economic impact (public benefits) relative to the *status quo* land use	IUCN and WRI, 2014; Mansourian and Vallauri, 2014
Social	Takes into account landscape history and peoples' expectations	Suding et al., 2015; Mansourian and Vallauri, 2014
	Beneficial to countries or communities with a historical cultural connection to forests (e.g., forest-based traditions and folklore, forest-based livelihoods and employment)	IUCN and WRI, 2014; Mansourian and Vallauri, 2014
	Provides a way for governments to meet commitments to international agreements (e.g., UNFCCC and REDD+, UNCCD, CBD, Bonn Challenge)	IUCN and WRI, 2014
Policies and strategies		
Legal foundation	Secure tenure	IUCN and WRI, 2014; Mansourian and Vallauri, 2014
	Restoration is required	IUCN and WRI, 2014
	Restrictions exist on clearing native forests	IUCN and WRI, 2014
Supportive policies	Policies affecting land use are aligned and streamlined (e.g., lack of conflict between resource sector ministries such as agriculture, forestry, or mining)	IUCN and WRI, 2014
	Supports sectoral adaptation	Travers et al., 2012
	Complements infrastructure adaptation	Travers et al., 2012
Effective enforcement	Laws affecting natural resources are understood by relevant actors (e.g., police and courts) and are enforced in a visible, credible, and fair manner	IUCN and WRI, 2014,

Enabling conditions		
Ecological	Soil, water, climate, and wildfire conditions are suitable for restoration	IUCN and WRI, 2014
	Plants and animals that can impede restoration are absent	IUCN and WRI, 2014
	Native seeds, seedlings, or source populations are readily available	IUCN and WRI, 2014
Economic	Competing demands (e.g., food, fuel) for degraded forestlands are declining	IUCN and WRI, 2014
	Value chains for products from restored forest exist	IUCN and WRI, 2014
Social	Local people are empowered to make decisions about restoration	IUCN and WRI, 2014
	Local people are able to benefit from restoration	Chan et al., 2007; IUCN and WRI, 2014; Mansourian and Vallauri, 2014
Institutional	Effective institutional coordination is in place	IUCN and WRI, 2014
	Policies avoid maladaptation to future climate	Travers et al., 2012
	Policies reduce risk and disasters	Travers et al., 2012
	Adaptive governance arrangements	
	Restoration "know-how" exists	IUCN and WRI, 2014
	Restoration "know-how" transferred via peers or extension services	IUCN and WRI, 2014
	Adequate administrative capacity and resources	
	Enabling infrastructure in place (e.g., seedling nurseries)	
Financial	"Positive" incentives and funds for restoration outweigh "negative" incentives for *status quo*	IUCN and WRI, 2014,
	Incentives and funds are readily accessible	IUCN and WRI, 2014,
	Long-term economic viability	Mansourian and Vallauri, 2014

4.2 Policies and Strategies

Policies and strategies that make for successful FLR include a secure legal foundation, supportive national and sub-national policies, and effective enforcement of the laws governing use of natural resources (IUCN and WRI, 2014). Critical legal aspects that affect restoration as well as mitigation activities such as REDD are tenure and use rights, and participation by those affected (including Free Prior and Informed Consent; (Barr and Sayer, 2012)). For many rural populations in developing countries landscape restoration inside and outside forest land is often more a question of governance, equity, and rights as it is a technical question of planting trees (Holden et al., 2013a; Robinson et al., 2014). Unfortunately, this can lead to the wrong conclusion that the technical part is easy and needs less – or even no – attention, leading to wide spread planting disasters (Graudal and Lillesø, 2007).

Secured land tenure rights contribute to improving livelihoods of local communities. Photo © Louis Bernard Cheteu

4.2.1 Legal Foundations and Tenure

Legal foundations for restoration relate essentially to land tenure and rights of access to resources but also to such elements as incentives or policy requirements that encourage, promote or require restoration. Importantly, restrictions on clearing native forests may be needed to avoid unintended negative consequences of restoration or climate change mitigation. For example, in Indonesia the forest law has allowed clearing of secondary forests for oil palm plantations (Edwards et al., 2012), because secondary forests are classified as "degraded," regardless of their actual condition or the ecosystem services they can provide (Barlow et al., 2007; Bongers et al., 2015). In contrast, in Paraguay a law to restore riparian forest exists and is promoted via the provision of saplings from tree nurseries (Mansourian and Vallauri, 2014).

In some societies, forest and land ownership and use rights are well defined and enforced by the rule of law. In other instances, particularly in tropical countries, the tenure relations are far more complex and corruption is endemic (Kolstad and Søreide, 2009). The colonial past of some tropical countries contributed to the opacity of land tenure arrangements; but in other countries that past provided a formal framework for defining current tenure relations (Borras Jr and Franco, 2012; Lamb et al., 2005). Land tenure is generally understood as the mutually accepted terms and conditions under which land is held, used, and traded. Further complications arise when ownership of the forest, trees, or fruit from certain trees is separate from tenurial rights to the land. It is important to note that land tenure is not a static system; it is a system and process that is continually evolving, and is influenced by factors such as the state of the economy, changing demographics, cultural interactions, political discourse, or a changing natural and physical environment (Murdiyarso et al., 2012). However, land tenure can, in turn, have an impact on these factors, which is why it should be considered in conversations concerning forest restoration, socioeconomic development, and environmental change (Mansourian and Vallauri, 2014). Box 4.1 provides a brief, simplified example from Ghana (Blay et al., 2008; Damnyag et al., 2012; Hansen et al., 2009; Teye, 2011; Wardell and Lund, 2006).

Formal use rights and ownership by communities and individual smallholders are increasingly important as forest resources dwindle and forests are converted to other land uses (Barr and Sayer, 2012; Borras Jr and Franco, 2012; Roe et al., 2013). As a consequence, attempts at restoration of forests in the tropics must deal with the ownership and user rights first. In particular the overlapping claims by customary tenure and national legal codes on forest land need to be resolved through community participation in mapping of lands and forest resources managed under customary tenure systems.

Tentative and changing terms of tenure lead to uncertainty and short planning horizons. Short-term planning is less likely to entail large investments in productive assets or adoption of new technologies, as there is little opportunity for a tenant to capture any benefits from long-term investments. The same is true for investments in restoration and sustainable forestry. Thus, insecure tenure often leads to land degradation and is economically unsustainable in the long term (Hayes et al., 1997; Robinson et al., 2014). The implications for forest restoration are similar to those for sustainable forestry: seeing little potential short-term benefit from a restored forest, a farmer may be indifferent or even hostile to a restoration project (Damnyag et al., 2012; Hansen et al., 2009). Recognizing these barriers to tree planting and private forest management in general, alternative benefit-sharing schemes such as modified taungya have been developed along with community participation in forest management and restoration (Agyeman et al., 2003; Blay et al., 2008; Schelhas et al., 2010).

Box 4.1

Land Tenure in Ghana

All land in Ghana can be considered occupied, in the sense that it has been claimed, over centuries, by tribes and lineages. Throughout colonialism and into Ghana's statehood, some of this land was seized and claimed for private ownership, and eventually state ownership. As a result of both long-standing ancestral systems of land governance, and the need for state-managed lands, Ghana has developed two distinct forms of land governance: statutory tenure and customary tenure. Statutory tenure provides for tenure rights that are legally enforceable in a Ghanaian court of law, regulated, and well documented. The customary system, by contrast, is largely undocumented, highly variable, and rights and leases granted through customary authorities are rarely legally enforceable in a court of law. Customary tenure laws govern lands belonging to tribes, lineages, and families. Ownership of these lands is vested in chiefs and lineage heads but technically tribal land is ancestral property and therefore belongs to the people (Gildea, 1964). In forested southern Ghana, an individual validates and maintains tenure by clearing the forest, sometimes beyond immediate needs. The decline in traditional resource management system supported by animist religious beliefs is also having detrimental environmental effects (Sarfo-Mensah and Oduro, 2010).

Ghana's constitution vests all minerals and natural resources (including trees) in the president, regardless of whether or not the resource is on public or private land. Customary and statutory laws, while granting ownership of the land, do not grant ownership over naturally-occurring resources that the land holds (Owubah et al., 2001). Outside of forest reserves, harvesting and selling merchantable trees is illegal unless an individual has gained permission – through a lengthy process - from the Forestry Commission. Protecting valuable, naturally-occurring trees is not generally in a farmer's interest, however, because loggers (who have been granted a concession by the Forestry Commission) who come to harvest them often damage food and cash crops, and rarely compensate farmers for these losses, despite legal requirements to do so. This system creates an incentive for farmers to cut down merchantable trees before loggers can reach them; thereby undermining sustainable forestry practices (Owubah et al., 2001). If a farmer plants trees on the land, he/she can seek a title for that tree from the Forestry Commission, in which case he/she owns it outright, can cut and sell it, and keep all profits; but since obtaining title in practice is time-consuming and costly he/she may instead sell it to an illegal logger (Hansen, 2011; Hansen and Treue, 2008).

4.2.2 Supportive Policies

Policies affecting land use are often interpreted and implemented by multiple agencies and this may lead to conflicts, particularly between resource sectors such as agriculture, forestry, or mining. A supportive policy environment is needed for long-term sustainability of FLR projects, for example to avoid situations where one agency grants a permit to a concessionaire to use land in a way that disrupts or diminishes the value of restoration permitted by another agency (Emborg et al., 2012; Redpath et al., 2013). While all use conflicts cannot be avoided, procedures in place to allow (or require) review and comment by resource agencies on infrastructure development by another agency, for example, may result in minimized overall loss of ecosystem services and/or investments in restoration (Emborg et al., 2012). Environmental reviews such as impact assessments have a long history in some countries and may be required by donor organizations such as the World Bank (but see Buntaine (2015) for a critique of their effectiveness).

In some cases, even natural resource policies might conflict with FLR activities. For example, laws governing protected areas might prohibit collection of seeds of native species but there may not be other sources in a degraded landscape. Lack of alternative sources for seed to produce seedlings in a nursery can inhibit efforts to restore native species (Lillesø et al., 2011; Thomas et al., 2014). Cumbersome regulations and paperwork may inhibit small landowners or users from undertaking restoration. Simply requiring people to travel to the national or provincial capital to secure necessary permits can impose an intolerable burden on small farmers (e.g., the tree tenure example in Ghana in Box 4.1).

Increasingly, flood and coastal protection policies are changing and using "soft engineering" approaches that combine structures and restoration of natural systems (Borsje et al., 2011) in riverine and coastal environments (Alongi, 2008; Thampanya et al., 2006; Zhang et al., 2012). Forest landscape restoration can complement infrastructure development aimed at climate change adaptation. For example, mangrove restoration (Bosire et al., 2008; Lewis, 2005), structural protection, afforestation, and watershed rehabilitation can be combined to prevent flooding and soil erosion as well as sequester carbon (Dang et al., 2003; Swart and Raes, 2007).

4.2.3 Effective Enforcement

Supportive and enabling laws and policies are moot unless they are enforced in a visible, credible, and fair manner. This requires that laws affecting natural resources are understood by relevant actors, for example the police and courts. Corruption and inconsistent application of natural resource laws is a problem in some developing countries (Kolstad and Søreide, 2009). Inequitable allocation of benefits due to elite capture is a less obvious form of corruption but one that may be more amenable to corrective outside influence (Persha and Andersson, 2014; Platteau, 2004). Enforcement is clearly of value in avoiding further degradation and in the long-term, necessary to protect restored areas.


Degraded Pama Berekum Forest Reserve in Ghana. The forest reserve was degraded by harvesting without adequate regeneration, followed by wildfire and invasion of an exotic grass. Restoration by local farmers with native trees using the modified taungya system. Photos © John Stanturf

4.3 Enabling Conditions

4.3.1 Ecological

Restoration methods should be adapted to local soil, water, climate, and wildfire conditions (Stanturf et al., 2014a). Nevertheless, the necessary knowledge of site requirements for a native species, for example, may be lacking, making successful establishment improbable unless specific research is undertaken (Thomas et al., 2014). Even when the requirements are known, scaling up from research plots to operational restoration can be difficult, as experienced in the early days of bottomland hardwood restoration in the Lower Mississippi Alluvial Valley, USA.

Competing vegetation, especially invasive species, may prevent natural regeneration to restore large areas and reduce survival of planted seedlings (Stanturf et al., 2014a). Of special concern are plants such as some highly flammable grasses that promote wildfires, maintaining degraded conditions (D'Antonio and Vitousek, 1992). In Ghana, the invasive *Chromolaena odorata* captured sites following logging and initiated a fire cycle that precluded natural regeneration or recolonization of Forest Reserves. Grazing animals, both domestic and wild, can impede restoration if they are not excluded by fencing or active herding.

Several methods of artificial and natural regeneration at different scales require that native seeds, seedlings, or source populations are readily available. Assisted Natural Regeneration, including Farmer Managed Natural Regeneration (Stanturf et al., 2014a), will similarly benefit from enrichment with additional species that may be locally absent, perhaps due to dispersal limitations of heavy-seeded species. Small and large-scale plantations and agroforestry gardens, whether for production of timber, energy wood, food, forage or other non-wood value products, all require sufficient seeds and seedlings to be available (see Box 4.1).

4.3.2 Economic

A major difference between developed and developing countries is the proportion of poor people living in rural areas and the proportional contribution of agriculture to the gross domestic product (WorldBank, 2007). Restoration in agriculturally-based countries will thus have large rural populations living in and near forests from which they derive forest products to sustain their livelihoods. Restoration may reduce their vulnerability to climate change (Dawson et al., 2014a; Pramova et al., 2012). The World Bank (2008) estimated that forests and trees on agricultural land contributed to the livelihoods of more than 1.6 billion people globally and smallholder farmers are major producers of some of the world's most important commodity crops that are grown in agroforests (coffee, cocoa, tea, rubber, and to some extent oil palm) (Byerlee, 2014). The large rural population in tropical countries represents an important target for tree planting on smallholders' private holdings (Zomer et al., 2014) with a view to increase their own resilience as well as contribute to climate adaptation and mitigation.

Competing demands for land for food, fuel, and infrastructure in an area may affect the viability of FLR projects. Globally, the future demand for land will increase with intensifying competition for agriculture, forestry, energy, and conservation land uses (Lambin and Meyfroidt, 2011; Smith et al., 2010). In the areas with the greatest potential for FLR, specifically in the tropics, many farmers are dependent on rain fed agriculture and lack the capital to intensify their production (Pretty and Bharucha, 2014). If climate change causes their crop yields to decline, they likely will adapt by clearing more land for cropping, at the expense of forests (Seto et al., 2012; Zabel et al., 2014).

4.3.3 Social

Barr and Sayer (2012) point out that forest restoration programs can be influenced by powerful political economic interests that have in some regions been accompanied by trade-offs and a host of governance challenges. In planning forest restoration activities, it is essential that the rights of local communities are addressed. Local stakeholders need to be actively engaged in decisions regarding restoration goals, implementation methods, and trade-offs. Prior informed consent should be integrated into the decision making process. It is important that the restoration process respects rights of local stakeholders, is aligned with their preferences for land management practices, and provides clear and sustained benefits. A well-designed process will benefit from the active voluntary involvement of local stakeholders.

Motivating landowners and communities can be the most critical part of forest landscape restoration in mosaic landscapes and it is on this count that many failures have occurred in the past. In the case of state forests where the ownership is exclusively government and most recurring and final harvest benefits accrue to the larger society, involving local communities may mean sharing a greater part of recurring benefits with them besides including them in general management decision making (Sayer et al., 2013). Some parts of degraded forests can be restored by speeding up succession processes towards more species rich, resilient and biodiverse forests that also produce significant benefits to the rural populations living in the vicinity and who will have an interest in maintaining the forests. Alternatively, these landscapes can be turned into agroforest landscapes with the primary objective of producing benefits for the people while retaining some elements of ecological benefits (Barr and Sayer, 2012).

4.3.4 Institutional

Smallholders in rural communities can be involved in forest landscape restoration on their own land or in participatory arrangements on public land (Colfer, 2011). In recent decades the increased pressure on natural resources has led to widespread claims on the ownership of forest lands, which in many parts of the world have been formally owned by governments and informally utilized by local people through customary use rights, at times resulting in the alienation of local people from their traditional lands (RRI, 2014; Kenney-Lazar, 2012). Smallholders in rural communities can be involved in forest landscape restoration on their own land or in participatory arrangements on public land. The rights and obligations of communities and forestry agencies vary considerably, depending upon geography and culture.

4.3.5 Knowledge and Capacity

Much knowledge that is taken for granted in developed temperate and subtropical countries - such as detailed descriptions of the flora, vegetation and provenance variation of indigenous tree species - are limited in the tropics (FAO, 2014; Graudal et al., 2014a; Mansourian and Vallauri, 2014). These knowledge constraints are exacerbated by the very rich flora and abundant potentially useful tree species. Additionally, well-functioning economic networks of tree seed producers and nurseries, along with the frictionless flow of knowledge among producers and consumers, are needed to enable implementation of landscape level restoration strategies. Thus, the capacity of public sector agencies must be strengthened both with respect to producing knowledge of species and effective practices and to make the knowledge available throughout the whole value chain from the seed source to final users.

Restoration knowledge may be transferred via peers, extension services, or NGOs. One of the goals of the Global Partnership on Forest Landscape Restoration (GPFLR) is to develop and maintain a learning network of FLR projects (van Oosten, 2013). While some knowledge transfer can occur using electronic media (web sites, email, etc.), the most effective transfer occurs in face-to-face encounters augmented by local demonstrations of effective practices (Elliott et al., 2012; Gardiner et al., 2008).

Many restoration projects are implemented by local people as volunteers or hired laborers. Alternatively, large-scale projects might be implemented by contractors. Adequate and properly trained labor for planting trees is critical for ensuring good survival and restoration success. When planting depends on the labor of local farmers, there may be conflicts when the planting season for trees and crops overlap. Monitoring survival and basing payments on achieving minimum survival rates is necessary to ensure success.

Another important requirement of establishing a successful landscape restoration program is a set of strong supportive institutional arrangements behind the implementing agency. This could include land-based and remotely-sensed surveying, soil testing, linkages with markets for forest products and for ecosystem services such as carbon, capacity building, forest management and social research, and sharing the knowledge generated among the stakeholders. Necessary enabling conditions for initiating FLR include adequate infrastructure (e.g., seedling nurseries), proper materials (native seeds or climate-adapted germplasm), and available labor (at optimal planting time and if needed, for site preparation and post-establishment tending).

Enhancing access to native seeds by improving the logistics of their collection, storage and supply, and production of high quality planting stocks in nurseries are other important tasks that would need priority engagement of government agencies such as the forest department. For anticipatory adaptation, research on climate-adapted germplasm should be emphasized on which very little work has so far been done in the developing world. A key to creating necessary enabling conditions is that utilization of quality seeds or seedlings needs forward planning, coordination, and investment (see Box 4.2). The term "quality seed" implies relevant and useful material of species for the

Tropical natural forest regeneration – tending operations of saplings. Photo © Michael Kleine

objectives of restoration; that the seed will produce trees that are genetically adapted to the planting site; and the trees will generate products (whether for commercial or conservation purposes) within an acceptable time span and of an acceptable quality (Graudal and Lillesø, 2007; Lillesø et al., 2011).

4.3.6 Financial

Adequate funding for restoration means several things. First, the costs of the proposed restoration treatments must be met and the funds must be readily accessible. Internal bureaucratic obstacles to funds being transferred and available to pay workers and suppliers can stymie restoration projects. For example, a project that includes planting seedlings often has a seasonal constraint with the optimal window for planting being only one or two months in the year. Working back from this deadline, procuring planting material, arranging for site preparation, and contracting for planting crews means that funding must be available for payments as much as a year (more if the nursery infrastructure needs to be developed) in advance of the work commencing. Any delays in getting money transferred to accessible accounts could mean delaying a project for a year. Funding frequently runs out for the maintenance and long-term management of restored trees, leading to poor results in the long-term (Mansourian and Vallauri, 2014).

Positive incentives and funds for restoration should outweigh any negative incentives that favor the *status quo*. Positive incentives usually can be readily identified and might include grants, loans, tax breaks, or subsidies from the government or NGOs. Payments for ecosystem services such as carbon or markets for goods and services (e.g., ecotourism) may need time to appear. Negative incentives for restoration might be positive incentives to other resource users, such as grants, loans, tax breaks and commodity support payments for grazing, agriculture, or mining. Less obvious negative incentives include practices such as in some countries where land tenure is secured by land clearing, resulting in more land being cleared than a farmer can presently cultivate. Other disincentives relate to tree tenure or harvesting restrictions (see Box 4.1 for example from Ghana). For example, in some countries where trees can only be harvested if damaged by wildfire, fires are intentionally set in order to "legally" harvest timber to meet local needs and for commercial purposes.

The economic feasibility of forest restoration at landscape levels is also critically important. In developing countries not enough thought has been given to this aspect and often restoration is expected to be undertaken

Box 4.2

Supply of Adequate Reproductive Material for Restoration

High quality reproductive material is rarely available to smallholder farmers. Breeding for smallholders needs to be provided as common good and a strong public-private partnership could be suitable for many trees species by investing in centralized quality seed development and by supporting a decentralized system of nurseries producing and distributing seedlings for multiple FLR projects. The need to breed for adaptation to future climate is essential but this requires a multinational effort to mobilize and build the tree genetic resources for the future. Within a nation or region, a breeding program for more than 50 priority species would include identification of distribution and deployment zones under current and future climatic conditions. Range-wide collections of priority species could be of plus tree families (from natural stands as well as possible landraces) complementing existing collections. Breeding seedling orchards (BSOs) could be designed and established in relevant deployment zones for combined provenance/progeny testing and seed production/multiplication/conservation.

Creating sustainable networks for production and distribution of quality seeds and seedlings requires substantial institutional changes to the way most restoration projects incorporating tree planting operate (Graudal and Lillesø, 2007). Production of tree seedlings should be planned for at a landscape scale, which is much larger than most individual restoration projects. Because most trees are planted as seedlings, networks of economically viable nurseries are required that have access to knowledge of seed procurement, treatment and handling, and storage. Generally, this cannot be handled efficiently by small individual projects because of their short time frames. In particular in dry land restoration projects, seedlings may need a relatively long time (even years) in the nursery before they develop to the necessary size to survive outplanting. A blend of organizational alternatives, depending on species and target groups, is preferred (Louwaars and de Boef, 2012; Maredia et al., 1999; Minot et al., 2007).

at public expense and with no expectation of economic returns. However, sooner rather than later developing countries run out of money, often because they have more pressing priorities, and restoration remains confined to small areas in place of the large-scale results that are needed if real headway has to be made in this daunting task. The only country that has continued uninterrupted with restoration has been China (Wenhua, 2004; Xi et al., 2012), which may be a result of its political system. One way to ensure long-term viability is to embed restoration in existing frameworks (Mansourian and Vallauri, 2014). China provides the example of the Grain for Green program, where reforestation of steep slopes presented an opportunity to pursue FLR within a long-term environmental program (Mansourian and Vallauri, 2014; Xi et al., 2012). Historically, there are cases of showing successful restoration even where resources initially were scarce, as demonstrated by the Danish case. The mixed Danish forests arose over a period of 200 years from a seriously destroyed landscape (Mather et al. 1998; Madsen et al. 2005). Comparable developments have taken place elsewhere (Bae et al., 2012; Plieninger et al., 2012; Mather 2007) including initially poor regions with high human population density (Rudel, 2009).

Chapter 5
Restoration Activity to Promote Mitigation and Adaptation

In an attempt to better understand the role of forest landscape restoration in adaptation and mitigation, we developed a list of mitigation and adaptation activities from numerous sources that we deemed relevant to forest landscape restoration (Table 5.2 and Table 5.3). Restoration activities are grouped according to climate change goal (mitigation or adaptation), with specific objectives under each goal and the mechanism for achieving each objective. Activities are further classified by the spatial level at which they are applied—species, stand, landscape, or national/international. Activities at the national/international level include policies that need to be enacted or reformed, or to enabling conditions. At the lowest spatial scale, that of individual species, activities relate to utilization, such as markets for non-timber forest products or forest-based value chains. Additionally, activities at the species-level may be related to choosing a species to plant that is productive or using species or provenances that are better adapted to current or future climate. Because most restoration activities involve manipulating vegetation, activities at the stand- and landscape-levels are where interventions are designed and implemented (DeRose and Long, 2014). Activities listed are necessarily general and some activities may require intervention at multiple scales; specific methods and techniques are sensitive to local ecological and social contexts and specific information is available in the literature (Stanturf et al., 2014a).

5.1 Restoration Activities to Promote Climate Mitigation

Climate change mitigation has two general objectives: sequester carbon in long-term storage or reduce the amount of carbon and other greenhouse gases (GHGs) released to the atmosphere (Table 5.1). Emissions from fossil fuel combustion, biomass burning, and land use change all contribute to the increases in GHG emissions causing global warming (IPCC, 2003). Mechanisms for sequestering carbon include increasing the forest area and the biomass per unit area. Forest area can be increased by passive (recolonization) or active means (e.g., farmer-assisted natural regeneration, agroforestry or afforestation). Purely mitigation objectives may tend to utilize fast growing species, although more adaptive options would provide biodiversity and other benefits without greatly reducing the amount of carbon storage (e.g., combining fast-growing nurse crops with slower growing but longer-living species (Löf et al., 2014).

Restoration activities in degraded forests that provide mitigation benefits include increasing productivity or the amount of aboveground biomass. Many standard forest management practices can increase productivity, from selecting more productive species or longer-lived species, increasing stem density, using nurse trees, improved planting material, or lengthening the rotation or cutting cycle in production forests (Graudal et al., 2014b; Stanturf et al., 2014a). Two methods for directly increasing the amount of carbon stored in soil include introducing species with greater rooting depth (Canadell et al., 1996) or adding biochar (Sohi et al., 2010). Other restoration activities to increase soil carbon include reducing losses, through implementing conservation measures in management practices or by establishing windbreaks to counter wind erosion. Mixed plantings can also increase productivity (Hulvey et al., 2013b).

Mitigation activities include carbon offsets through substitution for fossil fuels or unsustainably harvested wood, and by offsets from use of wood products rather than steel, cement, or plastic (Ravindranath, 2007). Land use change, including deforestation and forest degradation, is a major cause of carbon emissions (Cochrane and Laurance, 2008; Mahmood et al., 2014; Pielke et al., 2007; Pielke et al., 2011) and the major drivers for deforestation appear to be increasingly associated with demand for agricultural products from urbanization and agricultural exports (DeFries et al., 2010; Meyfroidt et al., 2010; Rudel, 2007; Rudel, 2013). Although the rate of total global forest cover

Table 5.1

Mitigation opportunities relevant to forest restoration

		Mitigation[1]	
Objective	**Mechanism**	**Restoration Activity**	**Level[2]**
Sequester carbon	Increase forest area	Recolonization	TL
		Farmer-assisted natural regeneration	STL
		Agroforestry (agroforestation)	ST
		Afforestation	STL
	Increase biomass/ unit area	Increase productivity	ST
		Introduce longer-lived species	ST
		Lengthen rotation or cutting cycle	STL
	Increase soil carbon	Introduce species with greater rooting depth	S
		Implement soil conservation measures that reduce erosion	TL
		Establish windbreaks to reduce wind erosion	TL
		Add biochar	T
Reduce fossil fuel emissions	Bioenergy	Firewood, charcoal, and forest residues	TN
		Bioenergy plantations	TLN
	Substitute materials with greater carbon footprint	Producing wood-based bioproducts (e.g. construction materials, bioplastics)	N
Reduce emissions from biomass burning	Control GHG emissions from wildfire	Prescribed burning and holistic fire management	TLN
		Convert to fire resistant species	STL
	Increase biofuel use efficiency	More efficient stoves, power plants, and conversion technology	N
		Improve charcoal production	TLN
Reduce emissions from land use change	Reduce deforestation drivers	Policy reforms to promote increasing trees in the landscape (e.g., secure tenure)	TLN
		Effective protection (e.g., conservation easements, improved enforcement)	TLN
		Improve native forest management employing sustainable forest management principles	TLN
		Utilize existing programs for local forest management (community forests, joint forest management, participatory forest management, etc.)	TLN
		Reduce illegal logging	TLN
		Reduce escaped fire	TLN
		Manage or exclude grazing	TLN
		Prevent agricultural encroachment	TLN
		Increase agriculture, agroforestry, pasture productivity and profitability	STLN
		Improve smallholder access to climate-adapted inputs and markets	STLN
		Promote forest-based value chains (especially for non-timber forest products)	SLN

[1] Based on Stanturf, 2015 with additions from other sources
[2] Spatial hierarchy of activities: S=species, T=stand, L=landscape, N=national or international

decrease has diminished (FAO, 2010), deforestation is regionally significant (e.g., Sub-Saharan Africa, (Kelatwang and Garzuglia, 2006) and globally more than 2 billion ha of forests are degraded (Lindenmayer et al., 2012; Minnemeyer et al., 2011).

Carbon conservation activities include policy reform to reduce deforestation drivers, conferring some form of protection status on existing forests (e.g., formally designated protected areas such as national parks or game management areas), and promoting sustainable forest management (including practices such as integrated wildfire management or reduced impact logging). Over 12 % of forests globally are legally reserved (FAO, 2010), however they are often degraded or threatened by encroachment in countries where ownership is contested, enforcement is lax, and protected areas are underfunded and understaffed (Laurance et al., 2014; Le Saout et al., 2013; Leverington et al., 2010; Terra et al., 2014). Restoration inside protected areas is increasingly being recognized as an important management tool for achieving the objectives of the protected area, notably for its resilience and improving habitat for species to adapt in the face of future climate change (Keenleyside et al., 2012).

5.2 Restoration Activities to Promote Climate Adaptation

The adaptation objective to maintain forest area can be achieved by reducing or removing deforestation and degradation drivers that lead to conversion of forest to other land uses. Restoration strategies have different temporal perspectives, that is, the restoration goal may be an historical ecosystem (incremental adaptation), a system adapted to current conditions and resilient in the face of climate change (anticipatory adaptation) or one adapted to novel future conditions (transformational adaptation). Addressing governance issues may be required before adaptive restoration can begin (Damnyag et al., 2012; Hayes et al., 1997; Robinson et al., 2014). Within the government, intra-ministerial conflicts may impede sustainable management of existing forests when other agencies (e.g., agriculture or mining) grant development access to reserved forests.

Adaptation also has a spatial aspect. For example, maintaining forest area by reducing deforestation drivers (Table 5.2) may require national policy reform (e.g., Brazil) to curtail financial incentives to convert native forests to pasture for cattle. In a landscape, policy reforms may result in increased tenure security, which motivates investment in intensification of agricultural practices, thereby increasing crop yields on land already cleared and reducing the need to clear more land to compensate for reduced yields under altered climate. At a local (stand) scale, providing farmers with unambiguous ownership to planted trees both removes incentives to illegally fell trees that spontaneously regenerate on field margins and provides incentives to engage in agroforestry by planting trees on cropland.

Forest degradation in the tropics. Land use change, including deforestation and forest degradation, is a major cause of carbon emissions. Photo © Stephanie Mansourian

5.2.1 Maintain Forest Area

Degrading actions that occur at the stand- or landscape-level can lead to loss of forest cover but can be reduced by timely adaptive actions. These degrading actions include escaped agricultural or arson fires, overgrazing, agricultural encroachment at the forest margins, or illegal logging or felling for charcoal manufacture. Effective protection of existing forests may require formally designating protected status, granting of conservation easements, or other measures. In all cases, effective enforcement is necessary to maintain forest area; without enforcement, protected status is meaningless (Terra et al., 2014). Nevertheless, people who depend on access and use of existing forests with long-standing *de facto* use rights need alternative livelihoods if their utilization of the forest is curtailed (Le Saout et al., 2013; Terra et al., 2014). Simply declaring an area protected, without accommodating local people's needs, may not maintain forest area in the long run. Positive factors such as improved access to markets and increased productivity of other land uses such as agriculture, pasture, and agroforestry may reduce pressure on existing forests (Laurance et al., 2014; van Noordwijk et al., 2008; Verchot et al., 2007).

5.2.2 Maintain Carbon Stocks

Maintaining existing carbon stocks by reducing deforestation or avoiding forest degradation, as well as additional carbon sequestered by mitigation activities, is another adaptation objective. Reducing deforestation or avoiding forest degradation can be accomplished by many restoration activities at all spatial scales. Policy reforms may be needed in some countries to avoid clearing secondary native forests and planting industrial tree crops such as oil palm, under the guise of restoration. Where logged primary forests are classified as "degraded," the door is open for clearing and reforestation, even with palm oil (Putz and Redford, 2010). Undoubtedly there are secondary forests that are truly degraded, in the sense that they no longer function to provide a minimally acceptable level of ecosystem services. Conversely, many secondary forests are highly functional and well on their way to natural recovery

Table 5.2

Adaptation opportunities relevant to forest restoration

		ADAPTATION (Incremental and Anticipatory)[1]			
Objective	**Mechanism**	**Restoration Activity**	**I[2]**	**A[2]**	**Levels[3]**
Maintain forest area	Reduce deforestation drivers	Policy reforms to promote increasing trees in the landscape (e.g., secure tenure)	×		TLN
		Effective protection (e.g., conservation easements, improved enforcement)	×		TLN
		Improve native forest management employing sustainable forest management principles	×		TLN
		Prevent agricultural encroachment	×		TLN
		Reduce escaped fire	×	×	TL
		Manage or exclude grazing	×	×	TLN
		Reduce or avoid fragmentation	×		TLN
		Reduce illegal logging	×		TLN
		Promote forest-based value chains (especially non-timber forest products)	×		SLN
		Improve smallholder access to climate-adapted inputs and markets	×	×	STLN
		Increase agriculture, agroforestry, pasture productivity and profitability	×	×	STLN
Maintain carbon stocks	Reduce or avoid degradation	Policy reforms to avoid clearing native forests (e.g., functioning secondary forests cleared for oil palm)	×		LN
		Policy reforms to promote increasing trees in the landscape (e.g., secure tenure)	×	×	TLN
		Utilize existing local participatory forest management programs (e.g., community forests, joint forest management)	×		TLN
		Implement sustainable forest landscape management	×	×	TLN
		Improve native forest management employing sustainable forest management principle	×		TLN
		Effective protection (e.g., conservation easements, improved enforcement)	×		TLN
		Protect native forests to enable local adaptation to climate change	×		TLN
		Use low-impact logging	×	×	TL
		Adjust harvesting levels to accommodate lowered productivity	×	×	TLN

[1] Based on GIZ, 2014; Bolte et al., 2009; Dumroese et al., 2015; FAO, 2013; Janowiak et al., 2014; Keskitalo, 2011; Kolström et al., 2011; Lindner et al., 2008; Spittlehouse and Stewart, 2004; Stanturf et al., 2014a; Stanturf, 2015)

[2] Adaptation activity: I=Incremental, A=Anticipatory

[3] Spatial hierarchy of activities: S=species, T=stand, L=landscape, N=national or international

Maintain carbon stocks	Reduce or avoid degradation	Protect soil from erosion or compaction	×	×	TL
		Reduce illegal logging	×		TLN
		Reduce or avoid fragmentation	×		TLN
		Prevent agricultural encroachment	×	×	TLN
		Manage or exclude grazing	×	×	TLN
		Reduce escaped fire	×	×	TLN
		Alter season of field burning	×	×	TL
		Manage fuel loads to avoid severe wildfire	×	×	TL
		Maintain or restore native fire regimes	×	×	TL
		Establish windbreaks to reduce wind erosion	×	×	TL
		Rehabilitate degraded stand structure	×	×	T
		Rehabilitate degraded stand composition	×	×	ST
		Restore natural disturbance processes (e.g., fire, flooding)	×	×	STL
		Favor species in native forests adapted to new and anticipated conditions	×		STL
		Manage vegetation to reduce water use and drought stress	×	×	ST
		Increase connectivity between forested patches	×	×	TL
		Increase structural and age diversity in the landscape	×	×	TL
		Increase species diversity in the landscape	×	×	STL
		Plant species or provenances adapted to new and anticipated conditions (plantations, enrichment plantings in native forests)	×	×	STL
		Modify seed transfer zones, relax rules governing movement of planting stock	×	×	STLN
		Increase agriculture, agroforestry, and pasture productivity and profitability	×	×	STLN
		Improve smallholder access to climate-adapted inputs and markets	×	×	STLN

Table 5.2

Adaptation opportunities relevant to forest restoration

		ADAPTATION (Incremental and Anticipatory)[1]			
Objective	**Mechanism**	**Restoration Activity**	**I[2]**	**A[2]**	**Levels[3]**
Maintain or improve other forest functions	Biodiversity	Expand reserves	×		LN
		Manage hunting (protect seed disperser or control herbivory)	×	×	TLN
		Manage for threatened, endangered, and species of concern	×	×	TLN
		Remove invasive species	×	×	TLN
		Protect species at edge of their ranges that may be better adapted to new climatic conditions	×	×	STL
		Silvicultural interventions to increase species diversity	×	×	STL
		Afforest, reforest, or agroforest with mixed species	×	×	STL
	Hydrology	Protect catchment areas, riparian areas to benefit downstream users	×	×	LN
		Maintain or establish ridge top forests to intercept mist and fog	×	×	TLN
		Design dams to allow sediment transfer to coastal wetlands	×	×	TLN
		Restore stream hydroperiod	×	×	LN
		Maintain or increase shade in riparian zones to counteract increased temperatures that risk aquatic species	×	×	TL
		Plant stream buffers	×	×	TL
		Protect soil from erosion or compaction	×	×	TL
		Install or repair check dams and contour trenches	×	×	TL
		Plant coastal margins to buffer storm surges	×	×	TLN
		Maintain salinity levels and adjust to increased sedimentation in mangroves	×	×	TL
		Design shore structures to allow longshore sediment drift	×	×	TLN

[1] Based on GIZ, 2014; Bolte et al., 2009; Dumroese et al., 2015; FAO, 2013; Janowiak et al., 2014; Keskitalo, 2011; Kolström et al., 2011; Lindner et al., 2008; Spittlehouse and Stewart, 2004; Stanturf et al., 2014a; Stanturf, 2015)

[2] Adaptation activity: I=Incremental, A=Anticipatory

[3] Spatial hierarchy of activities: S=species, T=stand, L=landscape, N=national or international

	Rural economy	Promote forest-based value chains (especially for non-timber forest products)	×		SLN
		Improve timber productivity	×	×	STL
		Improve production of non-timber forest products	×	×	STL
		Improve recreational and subsistence hunting	×		SLN
		Improve aesthetics to promote eco-tourism	×		SLN
Reduce vulnerability	Increase resistance and resilience to stressors	Thin to increase drought resistance	×	×	STL
		Integrated pest management	×	×	STL
		Design dams to allow sediment transfer to coastal wetlands	×	×	LN
		Maintain salinity levels and adjust to increased sedimentation in mangroves	×	×	LN
		Design shore structures to allow longshore sediment drift	×	×	LN
		Introduce new species or more climate-adapted provenances of existing species	×	×	STL
	Overcome regeneration barriers	Control herbivory	×	×	TL
		Enhance dispersal by removing barriers and creating connectivity	×	×	TL
		Genetically diverse seed sources available in the landscape for natural regeneration, colonization, or agroforestry planting	×	×	SN
		Modify seed transfer zones, relax rules governing movement of planting stock	×	×	SN
		Plant species or provenances adapted to new and anticipated conditions (plantations, enrichment plantings in native forests)	×	×	STL
		Develop genetically diverse germplasm that is climate-adapted (e.g., seed sources, provenances, or functionally equivalent non-native species)	×	×	SN
		Introduce genetically diverse germplasm that is climate-adapted	×	×	
	Assisted population migration	Reintroduce species within historic range that have become extirpated	×		STL
		Expand population within the historic range	×		STL
	Assisted range expansion	Expand just beyond historic range, mimicking natural range expansion		×	STL
	Create refugia	Identify and create microclimate refugia for in situ conservation of climate-threatened species		×	SLN

Maintaining forest area involves decisions and actions at several levels. Instead of destructive construction of roads, careful planning brings reduced environmental impact including forest area, watershed benefits and preventing natural disasters, such as landslides. Photos © Michael Kleine

(Chazdon, 2015), or may require only remedial measure such as enrichment planting (Ådjers et al., 1995; Elliott et al., 2012). Other policy reforms implemented at the stand, landscape, or national level to reduce or avoid forest degradation include securing tenure, implementing sustainable landscape (ecosystem) and forest management, and effective protection. In addition to maintaining current carbon stocks, adequately protecting existing forests may enable local adaptation to climate change by native species (Nicotra et al., 2010; Thomas et al., 2014; Valladares et al., 2014). Where current laws allow participatory forest management through mechanisms such as community forests, joint forest management, or wildlife conservation areas, integrating these efforts with local governance structures will increase the likelihood of success, as opposed to erecting new, stand-alone management structures.

Sometimes degrading activities are not severe or extensive enough to cause loss of forest cover but nevertheless they reduce carbon stocks. Avoiding encroachment and fragmentation, illegal logging, overgrazing, and severe wildfires are ways to maintain vegetation and stored aboveground carbon. Holistic fire management that integrates prescribed burning to manage fuel loads, suppression of escaped agricultural or arson fires, fire management including altering the seasons of field burning, education to prevent wildfire, or restoring native fire regimes are ways to maintain carbon stocks in fire-affected ecosystems (Brown et al., 2004; Fulé, 2008). Carbon stored in soil can be protected by minimizing soil disturbance through practices such as reduced impact logging and other measures to protect soil from compaction or erosion (Putz et al., 2008). Windbreaks will reduce wind erosion and have other beneficial effects on vegetation by reducing evaporation from the soil surface and protecting new plantings from abrasion. Managing water levels in peat swamp forest by avoiding or reversing drainage, will maintain soil carbon stocks (Burbridge, 2012; Miettinen et al., 2011).

Many restoration activities at the species-, stand-, and landscape-levels are designed to reverse degradation (Stanturf et al., 2014a; Stanturf et al., 2014b). Methods to rehabilitate degraded stand structure, composition, or restore natural disturbance processes are varied and may be used to achieve other goals besides climate change adaptation (Stanturf et al., 2014a). Additional activities specific to climate change adaptation are to favor species in native forests adapted to new and anticipated conditions or to plant adapted species or provenances based on diverse seed sources (Alfaro et al., 2014; Dumroese et al., 2015). Increasing diversity in stands and landscapes (species, intraspecific, structure, and age-class diversity) all work together to increase resilience in the face of climate change (Millar et al., 2007).

5.2.3 Maintain or Improve Other Functions

Maintaining or improving other forest functions, in addition to carbon stocks, also supports adaptation to climate change (GIZ, 2014; FAO, 2013; Spittlehouse and Stewart, 2004). Biodiversity, hydrology, and rural economy are other important forest functions that can be improved in forest landscape restoration. Biodiversity measures include those meant to protect individual species or habitat, such as expanding reserves, managing hunting, and removing invasive plants. Maintaining or increasing biodiversity can be achieved through several means, including protecting species at the edge of their range that may be adapted to altered climate, or specific silvicultural interventions such as enrichment planting, control of competing vegetation, or thinning to provide more light for understory or ground layer plants. Afforestation, reforestation, or agroforestry plantings using multiple overstory species or wide spacing to encourage colonization from intact forests can be implemented to increase biodiversity (Brockerhoff et al., 2008).

Forests provide both provisioning and protection functions in watersheds and hydrologic functioning can be conserved or restored in landscapes for local as well as regional benefits. Upland forests protect catchment areas that provide clean water to downstream communities, modulate stream hydrology to reduce flooding, and protect sloping lands from erosion or mass wasting (Bruijnzeel, 2004; Preti, 2013). In some ecosystems, forests on ridge tops greatly contribute to regional water balance by intercepting mist and fog (Nagy and Lockaby, 2012). Planting forested buffers along water bodies may have multiple benefits, depending upon local context (Bentrup et al., 2012). Buffers may increase shade and lower water temperature, stabilize stream banks, or fence livestock from the water body. Proper construction and maintenance of roads in order to protect soil from compaction and erosion maintains water quality. Riparian and coastal forests have been severely degraded by stream channelization and altered hydroperiod from dams, roads, and other flow impediments. Restoring free-flowing streams and rivers is often accompanied by restoration of floodplain and coastal forests (Hughes et al., 2012). In coastal areas in the tropics and sub-tropics, mangroves in low-energy coastal environments protect inhabitants from storm surges and often act as nursery areas for fisheries (Alongi, 2008). Mangrove restoration may require alteration of upstream dams and shore protection structures to maintain sediment balance. Anticipating shoreline recession (landward movement caused by sea-level rise) to allow mangroves to recede as well may require removing impeding structures or local zoning to exclude construction in coastal areas (Burbridge, 2012; Lewis, 2005).

Hillslope restoration in Korea. Harsh conditions (eroded soils, droughty sites) required restoration using a combination of physical water control structures to control erosion and tree planting. Photo © John Stanturf

Livelihood improvements may be critical to long-term sustainability of FLR projects. Short-term benefits may be necessary incentives for local communities to undertake restoration projects if agricultural or grazing land is taken for planting. The restored forest will more likely be sustained if long-term benefits are realized through improved productivity from timber and non-timber products, increased recreational or subsistence hunting opportunities, eco-tourism revenue or improved aesthetics.

5.2.4 Reduce Vulnerability

Vulnerability to disturbances such as drought, pests, or increased salinity can be reduced by increasing resistance or resilience at the species-, stand-, or landscape-levels; in some cases, national-level policy change will be needed to allow implementation at lower levels. Resistance at the stand-level is the influence of structure and composition on the severity of the disturbance; at the stand-level, it is the influence on spread of the disturbance and persistence of the system (DeRose and Long, 2014). Resistance to wildfire, for example, is expressed in fire severity as surface or low severity fire, stand replacing fire, or a mixed severity fire. At the stand-level, resistance to wildfire refers to the influence of stand structure and composition on fire spread.

Ecological resilience is the influence of the disturbance on the subsequent ecosystem. Stand-level resilience refers to the subsequent stand structure and composition while at the landscape-level; it is the proportion of landscape age classes and species that dominate (DeRose and Long, 2014). Resilience may differ between types of disturbances (kind and intensity), thus increasing resilience to drought by thinning may increase vulnerability to invasion by exotic grasses in a wet period. The restoration activities listed in Table 5.3 for increasing resistance and resilience can be applied to intact forest remnants in the landscape or as design criteria for restoring degraded forests. Controlling density, for example, may mean thinning an existing stand or planting at lower than traditional density in an afforestation project. At the species-level, introducing new species or provenances that are better adapted to changing climatic conditions is another way to reduce vulnerability by increasing resistance and resilience.

The most immediate effects of climate change likely will be on regeneration (Aitken et al., 2008; Pearson and Dawson, 2003). Overcoming regeneration barriers can lead to both incremental and anticipatory adaptation. Herbivory by domestic livestock and wild ungulates hamper regeneration of some forest species under current climate (e.g., deer in temperate forests, (Côté et al., 2004)) and herbivory may compound the vulnerability of some species that have lowered reproductive success in the future. Dispersal barriers may impede the ability of some species to migrate naturally under altered climate (Chen et al., 2011; Thomas, 2011). Even if impediments such as herbivory and dispersal barriers are removed, without genetically diverse seed sources for natural and artificial regeneration neither incremental nor anticipatory adaptation will be possible.

Planting species or provenances adapted to new and anticipated conditions is a widely discussed form of adaptation to climate change. In landscapes where planting is necessary for restoration or reforestation, rigid rules governing movement of planting stock or seed transfer zones that do not account for changing climate may need to be relaxed to allow for adaptation. This is already taking place in Canada (McKenney et al., 2009) and proposed in the western US (Dumroese et al., 2015). Developing climate-adapted germplasm can take advantage of existing breeding programs and techniques in order to introduce new provenances of native species or functionally equivalent non-native species to replace maladapted provenances. Moving plants in response to climate change has acquired a new vocabulary, termed "assisted migration", "assisted colonization", or "managed relocation" (see references in Dumroese et al., 2015). The scale of movement further defines the process. Assisted population migration refers to movement within a species' historic range and is primarily incremental adaptation to reintroduce an extirpated species or to expand the population to new areas within the range. Assisted range expansion, beyond the historic range, mimics natural migration but intentionally anticipates changed climatic conditions. Creating new refugial areas to maintain species' presence in the landscape, by identifying microsites where the species may persist, is another technique of anticipatory adaptation (Keppel et al., 2012).

Informed deployment (movement) of the genetic resources of trees requires that we know what the appropriate material for a given climate envelope may be and that such material is available. Suitability maps are needed for a greater range of species than are currently available (Kindt et al., 2014; Kindt et al., 2015) and the incorporation in breeding programs of climate-related traits (such as pest and disease resistance, drought resistance, fire tolerance, cyclone resistance, salt tolerance, and phenotypic plasticity) needs to be done more actively (Alfaro et al. 2014). So-called low input breeding (Lindgren and Wei, 2006; Kjaer et al., 2006, El Kassaby et al., 2012) combined with genomics (Alfaro et al., 2014; Wheeler et al., 2015) seem to point at an applied approach that can be used in support of restoration.

5.3 Transformational Adaptation

Transformational adaptations encompass novel ecosystems that arise spontaneously or are created by design (Table 5.3). Managing spontaneous novel ecosystems entails managing new assemblages that arise by the arrival of new species or the altered dominance of existing species. Warming climate has already caused large-scale insect outbreaks (Bentz et al., 2010) that are changing landscapes but it remains to be seen whether novel ecosystems will arise. Techniques for intentional creation of novel ecosystems range from policy changes that allow non-native or transgenic trees to be planted in areas where previously they were prohibited, to assisted species migration (long-distance movement outside historic range for the purposes of avoiding extinction (Dumroese et al., 2015; Williams and Dumroese, 2013)). Advances in biotechnology present possibilities of re-introducing extirpated or even extinct species (rewilding) or developing designer species by synthetic biology (Dumroese et al., 2015; Sarr and Puettmann, 2008). The potential to bring back mega-herbivores in an attempt to restore Pleistocene environments may seem farfetched and is certainly fraught with ethical challenges (Oliveira-Santos and Fernandez, 2010), nevertheless the techniques exist for creating new species with desired functional traits (Dumroese et al., 2015; Strauss and Bradshaw, 2004) or restoring keystone species using genetic modification (Jacobs et al., 2013; Seddon et al., 2014).

Neo-native ecosystems could arise by intentionally moving communities of native species to a new location in anticipation of climate change (Perring et al., 2013; Rout et al., 2013). Lunt et al. (2013) distinguished between push migrations to maintain taxa (e.g., assisted migration of a species far beyond its historical range (McLachlan et al., 2007; Pedlar et al., 2012; Williams and Dumroese, 2013) versus pull migrations used to restore a degraded site by adding a species (e.g., introducing a non-native species (Davis et al., 2011). Creating a truly novel (or designer) ecosystem would require establishing an assemblage of native and non-native species adapted to future climate (Hobbs et al., 2009).

Table 5.3

Transformational Adaptation[1]

Objective	Mechanism	Restoration Activity	Levels[2]
Manage novel ecosystems	Manage spontaneous ecosystems	Manage new species combinations that emerge (e.g., non-natives, altered dominance of natives)	STLN
	Create ecosystems	Policy that allows planting non-native species or transgenic trees	SN
		Assisted long distance species migration (well outside historic range)	STLN
		Create and plant new species that are climate-adapted (using synthetic biology) with desired functional traits	STLN
		Rewilding (re-introduce extirpated or extinct species)	STLN
		Ecosystem with novelty (replace native species with non-natives having desired functional traits)	STLN
		Neo-native ecosystems (moving communities of native species)	STLN
		Novel ecosystems (combinations of native and non-native species with desired functional traits; designer ecosystems)	STLN

[1] Based on Stanturf, 2015
[2] Spatial hierarchy of activities: S=species, T=stand, L=landscape, N=national or international

Chapter 6
Enhancing FLR Understanding

The contribution of forest and landscape restoration to climate change mitigation and adaptation consists of a wide array of policy, governance, and operational aspects – as presented in this report - that need to be addressed before a landscape can be improved to meet desired social, environmental, and economic objectives better, including those related to climate change. Because successful implementation of FLR depends on many motivated actors at different levels doing the right things, appropriate ways of promoting the understanding of FLR are needed including simple communication products, participatory planning, and joint evaluation of concrete landscape restoration initiatives in a given local context.

With these ends in mind, we developed a ”stoplight” tool for presenting the various FLR aspects and their relevance to climate change objectives. The tool can be seen as a necessary complement to the Rapid Restoration Diagnostic Tool developed by IUCN and WRI (2014). Tables 5.2 and 5.3 presented in this report (Chapter 5) add resolution to the enabling conditions and key success factors identified in the Restoration Opportunity Assessment Methodology (ROAM) developed by IUCN and WRI (2014). The added resolution will bring the user (whether planner, evaluator, or implementer) closer to the requirements of the actual field operations of forest landscape restoration, including the many complex technical problems that need to be dealt with following the participatory planning process involving both governance and implementation structures and institutions.

In this context, it is important to emphasize that not all of the mitigation and adaptation activities arrayed in Tables 5.1-5.3 will be appropriate for a given FLR project. Rather they are meant to encompass most of the potential activities that could be adopted in a given project that would provide reciprocal benefits and result in a climate-resilient, restored landscape. The stoplight tool is quite flexible and can be used in a number of ways, depending upon the complexity of an FLR project in terms of different stakeholders and ecological contexts and in the stage of development of the project (conceptualizing, planning, prioritizing, evaluating, or communicating). Selecting the activities that are potentially appropriate to a particular FLR project and presenting these with the stoplight tool provides a simple mechanism for:

- Promoting FLR as a means of climate change mitigation/adaptation among decision-makers and other stakeholders;
- Participatory planning of FLR projects involving many different stakeholders; and
- Evaluating FLR projects against pre-defined criteria and implementation standards.

In this chapter, we present examples of the use of the stoplight tool at different stages of a FLR project. These examples illustrate the flexibility of the tool but we caution that the meaning of the stoplight levels changes with the way the tool is used; that is, the colors may have different meaning, depending on the context. The way the stoplight is used in the ROAM procedure (IUCN and WRI, 2014), a color indicates a state in the progression toward achieving a goal; the aim is to have all “green” indicators. In most of the following examples, we use the stoplight differently, to evaluate activities in terms of whether or not they contribute to achieving a goal, or to compare among different project configurations. The stoplight can be used in two different ways. It can be used to answer the question of where we are in terms of (i) the status of implementing an activity (current implementation level), or it can be used to answer the question of (ii) where we want to go with a certain activity (prioritization). Ideally, one would always try to answer question (i) first and from there decide on question (ii). But in some cases there may be a need to answer question (ii) without having the answers to question (i). This can be illustrated graphically:

Where are we? Status of implementation	
In place	🟢
Partly in place	🟠
Not in place	🔴
Where do we want to go? Prioritization of future implementation	
Desirable	🟢
Maybe	🟠
Undesirable	🔴

6.1 Promoting FLR as a Means of Climate Change Mitigation/Adaptation

Past experience has shown that one of the biggest challenges in putting FLR into practice is reaching consensus among stakeholders on what is needed to achieve a desired set of objectives. In this context, Table 6.1 highlights an example of a stoplight tool as it could be used to present a hypothetical FLR project in a medium-sized landscape to decision-makers. Each activity is rated with a color: green for fully appropriate or desirable, red for not appropriate or undesirable, and yellow for a lower priority rating given to a particular activity.

6.2 Participatory Planning of FLR Projects Involving Many Different Stakeholders

The involvement of a wide range of stakeholders is essential for any FLR project to be successful. To this end, participatory planning and designing of projects with stakeholders can be facilitated by using the stoplight tools as described here. At an early stage, the full array of activities in Table 5.2 and Table 5.3 could be scanned by a design team who select all potentially appropriate activities. A stoplight matrix can then be developed as a design tool (an example is shown in Table 6.2) and presented to groups of stakeholders who assign consensus ratings to each activity: green for fully appropriate or desirable, red for not appropriate or undesirable, and yellow for possibly appropriate (perhaps not enough information is available to evaluate the activity or there is not a consensus among the stakeholders). The tool is here used for prioritization without assessing the feasibility in advance.

Larger FLR projects may involve multiple stakeholder groups. These may be geographically defined (for example, in different parts of a watershed) or by interest/livelihood sector (for example, smallholders, large landowners, conservation NGOs). Multiple columns might be used, each representing a stakeholder group (Table 6.3) with a final column representing an overall rating for an activity.

6.3 Evaluating FLR Projects against Pre-Defined Criteria and Implementation Standards

Another extension of the stoplight used for evaluating an FLR project could utilize multiple columns (Table 6.4), each representing an alternative project formulation. Each cell is then ranked by a design team or a stakeholder group in a fashion similar to that used in Table 6.1: green for fully appropriate or desirable, red means not appropriate or undesirable, and yellow means there is no consensus.

Alternatively, the columns might represent predetermined evaluation criteria rather than stakeholder evaluations. Using the stoplight tool in this way, each activity could be rated as to whether it provided a positive (green), negative (red), or neutral (yellow) effect on general sustainability criteria such as ecological, social, and financial benefit (Table 6.5) or the ”triple win” of mitigation, adaptation, and development co-benefits (Suckall et al., 2015). The criteria might be more specific, for example using program or donor agency criteria such as carbon sequestration, water supply, food security, cost feasibility, etc. In the same way, the stoplight tool could be used by a third-party auditing team to evaluate an FLR project.

Table 6.1

Communicating progress and promoting a hypothetical FLR project in a medium-sized landscape

	Objective	Mechanism	Restoration Activity	Implementation Level
Mitigation	Sequester carbon	Increase forest area	Afforestation	In Place
		Increase biomass/unit area	Increase productivity	Partly in Place
			Longer – lived species	In Place
		Increase soil carbon	Increase rooting depth	In Place
	Reduce emissions	Bioenergy	Bioenergy plantations	Partly in Place
Adaptation	Maintain forest area	Reduce deforestation drivers	Policy reform – wetlands drainage regulations	In Place
			Conservation easements	In Place
			Improve silviculture	Partly in Place
	Maintain carbon stocks	Reduce degradation	Sustainable forest management (improve regeneration)	Partly in Place
	Maintain other forest functions	Improve biodiversity	Afforest with mixed species	Partly in Place
			Recover endangered species (Louisiana black bear, pondberry)	Partly in Place
			Manage for species of concern (Neotropical migratory songbirds)	Partly in Place
		Improve hydrology	Restore microsites	Not in Place
			Plant stream buffers	Not in Place
	Manage for resistance	Reduce vulnerability to stressors	Integrated pest management of *Populus deltoides* only	Partly in Place
		Overcome regeneration barriers	Secure advance *Quercus* regeneration	Partly in Place
		Reduce vulnerability by breeding, introduce new provenances, genetic modification		Not in Place
	Manage for resilience	Expand population (within range)	Emphasize *Quercus* spp. in afforestation	Partly in Place
		Expand range		Not in Place
		Create refugia		Not in Place
Transformation	Novel ecosystems	Manage spontaneous ecosystems	Management of mixed plantings	Not in Place
		Create ecosystems	Translocate species	Not in Place
			Replace species within assemblages with desired functional traits	Not in Place
			Introduce exotics (non-native species) with desired functional traits	Not in Place

● In Place ● Partly in Place ● Not in Place

Using the stoplight tool to design an FLR project

Table 6.2

	Objective	Mechanism	Restoration Activity	Priority Level
Mitigation	Sequester carbon	Increase forest area	Afforestation	● Desirable
		Increase biomass/unit area	Increase productivity	● Maybe
			Longer – lived species	● Desirable
		Increase soil carbon	Increase rooting depth	● Desirable
	Reduce emissions	Bioenergy	Bioenergy plantations	● Maybe
Adaptation	Maintain forest area	Reduce deforestation drivers	Policy reform – wetlands drainage regulations	● Desirable
			Conservation easements	● Desirable
			Improve silviculture	● Maybe
	Maintain carbon stocks	Reduce degradation	Sustainable forest management (improve regeneration)	● Desirable
	Maintain other forest functions	Improve biodiversity	Afforest with mixed species	● Desirable
			Recover endangered species (Louisiana black bear, pondberry)	● Maybe
			Manage for species of concern (Neotropical migratory songbirds)	● Maybe
		Improve hydrology	Restore microsites	● Undesirable
			Plant stream buffers	● Maybe
	Manage for resistance	Reduce vulnerability to stressors	Integrated pest management of *Populus deltoides* only	● Maybe
		Overcome regeneration barriers	Secure advance *Quercus* regeneration	● Desirable
		Reduce vulnerability by breeding, introduce new provenances, genetic modification		● Undesirable
	Manage for resilience	Expand population (within range)	Emphasize *Quercus* spp. in afforestation	● Maybe
		Expand range		● Undesirable
		Create refugia		● Undesirable
Transformation	Novel ecosystems	Manage spontaneous ecosystems	Management of mixed plantings	● Desirable
		Create ecosystems	Translocate species	● Undesirable
			Replace species within assemblages with desired functional traits	● Maybe
			Introduce exotics (non-native species) with desired functional traits	● Undesirable

● Desirable ● Maybe ● Undesirable

Table 6.3

Multiple stakeholders using the stoplight tool to plan potential FLR activities

	Objective	Mechanism	Restoration Activity	Priority assigned by different stakeholder groups				
				1	*2*	*3*	*4*	*Overall Rating*
Mitigation	Sequester carbon	Increase forest area	Afforestation	Maybe	Desirable	Desirable	Desirable	Desirable
		Increase biomass/unit area	Increase productivity	Desirable	Maybe	Maybe	Desirable	Maybe
			Longer – lived species	Maybe	Desirable	Desirable	Desirable	Desirable
		Increase soil carbon	Increase rooting depth	Desirable	Desirable	Desirable	Desirable	Desirable
	Reduce emissions	Bioenergy	Bioenergy plantations	Maybe	Undesirable	Undesirable	Desirable	Maybe
Adaptation	Maintain forest area	Reduce deforestation drivers	Policy reform – wetlands drainage regulations	Desirable	Desirable	Desirable	Maybe	Desirable
			Conservation easements	Undesirable	Desirable	Desirable	Undesirable	Maybe
			Improve silviculture	Desirable	Maybe	Maybe	Desirable	Maybe
	Maintain carbon stocks	Reduce degradation	Sustainable forest management (improve regeneration)	Desirable	Maybe	Maybe	Desirable	Maybe
	Maintain other forest functions	Improve biodiversity	Afforest with mixed species	Desirable	Maybe	Desirable	Desirable	Desirable
			Recover endangered species (Louisiana black bear, pondberry)	Undesirable	Desirable	Desirable	Maybe	Maybe
			Manage for species of concern (Neotropical migratory songbirds)	Maybe	Desirable	Desirable	Maybe	Maybe
		Improve hydrology	Restore microsites	Undesirable	Desirable	Desirable	Maybe	Maybe
			Plant stream buffers	Undesirable	Desirable	Desirable	Maybe	Maybe
	Manage for resistance	Reduce vulnerability to stressors	Integrated pest management of *Populus deltoides* only	Maybe	Undesirable	Undesirable	Maybe	Maybe
		Overcome regeneration barriers	Secure advance *Quercus* regeneration	Maybe	Maybe	Desirable	Maybe	Maybe
		Reduce vulnerability by breeding, introduce new provenances, genetic modification		Undesirable	Undesirable	Maybe	Undesirable	Undesirable
	Manage for resilience	Expand population (within range)	Emphasize *Quercus* spp. in afforestation	Desirable	Desirable	Maybe	Maybe	Maybe
		Expand range		Undesirable	Desirable	Maybe	Undesirable	Maybe
		Create refugia		Undesirable	Desirable	Maybe	Undesirable	Maybe
Transformation	Novel ecosystems	Manage spontaneous ecosystems	Management of mixed plantings	Undesirable	Maybe	Maybe	Desirable	Maybe
		Create ecosystems	Translocate species	Undesirable	Undesirable	Maybe	Desirable	Maybe
			Replace species within assemblages with desired functional traits	Undesirable	Undesirable	Maybe	Desirable	Maybe
			Introduce exotics (non-native species) with desired functional traits	Undesirable	Undesirable	Maybe	Desirable	Maybe

● Desirable ● Maybe ● Undesirable

Evaluating desirability of alternative project formulations

Table 6.4

	Objective	Mechanism	Restoration Activity	Project Alternatives				
				1	*2*	*3*	*4*	*5*
Mitigation	Sequester carbon	Increase forest area	Afforestation	Undesirable	Desirable	Desirable	Desirable	Desirable
		Increase biomass/unit area	Increase productivity	Undesirable	Desirable	Desirable	Desirable	No Consensus
			Longer – lived species	Undesirable	Desirable	Desirable	No Consensus	Desirable
		Increase soil carbon	Increase rooting depth	Undesirable	Desirable	Desirable	No Consensus	Desirable
	Reduce emissions	Bioenergy	Bioenergy plantations	Undesirable	No Consensus	Desirable	Desirable	No Consensus
Adaptation	Maintain forest area	Reduce deforestation drivers	Policy reform – wetlands drainage regulations	Desirable	Desirable	No Consensus	Undesirable	Desirable
			Conservation easements	Desirable	Desirable	No Consensus	Undesirable	Desirable
			Improve silviculture	No Consensus	Desirable	Desirable	Desirable	No Consensus
	Maintain carbon stocks	Reduce degradation	Sustainable forest management (improve regeneration)	No Consensus	Desirable	Desirable	Desirable	No Consensus
	Maintain other forest functions	Improve biodiversity	Afforest with mixed species	Undesirable	Desirable	Desirable	Desirable	No Consensus
			Recover endangered species (Louisiana black bear, pondberry)	Desirable	Desirable	Undesirable	Undesirable	No Consensus
			Manage for species of concern (Neotropical migratory songbirds)	Desirable	No Consensus	No Consensus	No Consensus	No Consensus
		Improve hydrology	Restore microsites	Desirable	Desirable	Undesirable	Undesirable	Undesirable
			Plant stream buffers	Undesirable	Desirable	Undesirable	Undesirable	Undesirable
	Manage for resistance	Reduce vulnerability to stressors	Integrated pest management of *Populus deltoides* only	Undesirable	Undesirable	No Consensus	Desirable	No Consensus
		Overcome regenera-tion barriers	Secure advance *Quercus* regeneration	Undesirable	No Consensus	No Consensus	Desirable	No Consensus
		Reduce vulner-ability by breeding, introduce new provenances, genetic modification		Undesirable	Undesirable	No Consensus	Desirable	Undesirable
	Manage for resilience	Expand population (within range)	Emphasize *Quercus* spp. in afforestation	No Consensus	No Consensus	No Consensus	Desirable	No Consensus
		Expand range		Undesirable	Desirable	Undesirable	Undesirable	Undesirable
		Create refugia		Undesirable	Desirable	Undesirable	Undesirable	Undesirable
Transformation	Novel ecosystems	Manage spontaneous ecosystems	Management of mixed plantings	Undesirable	Undesirable	No Consensus	Desirable	Undesirable
		Create ecosystems	Translocate species	Undesirable	Undesirable	No Consensus	Desirable	Undesirable
			Replace species within assemblages with desired functional traits	Undesirable	Undesirable	No Consensus	Desirable	Undesirable
			Introduce exotics (non-native species) with desired functional traits	Undesirable	Undesirable	No Consensus	Desirable	Undesirable

● Desirable ● No Consensus ● Undesirable

Evaluating benefits using project criteria

Table 6.5

	Objective	Mechanism	Restoration Activity	Benefit Criteria*				
				M	A	D	F	W
Mitigation	Sequester carbon	Increase forest area	Afforestation	🟢	🟢	🟠	🟢	🟢
		Increase biomass/unit area	Increase productivity	🟢	🟠	🔴	🟠	🟠
			Longer – lived species	🟢	🟠	🔴	🟢	🟠
		Increase soil carbon	Increase rooting depth	🟢	🟠	🔴	🟢	🟠
	Reduce emissions	Bioenergy	Bioenergy plantations	🟢	🔴	🔴	🟠	🔴
Adaptation	Maintain forest area	Reduce deforestation drivers	Policy reform – wetlands drainage regulations	🟠	🟠	🔴	🟢	🟢
			Conservation easements	🟠	🟠	🔴	🟢	🟢
			Improve silviculture	🟢	🟢	🟠	🟠	🟠
	Maintain carbon stocks	Reduce degradation	Sustainable forest management (improve regeneration)	🟢	🟢	🟠	🟠	🟠
	Maintain other forest functions	Improve biodiversity	Afforest with mixed species	🟢	🟢	🟠	🟠	🟠
			Recover endangered species (Louisiana black bear, pondberry)	🔴	🟠	🔴	🟠	🟠
			Manage for species of concern (Neotropical migratory songbirds)	🔴	🟠	🔴	🟠	🟠
		Improve hydrology	Restore microsites	🔴	🟠	🔴	🔴	🔴
			Plant stream buffers	🟠	🟠	🔴	🔴	🟢
	Manage for resistance	Reduce vulnerability to stressors	Integrated pest management of *Populus deltoides* only	🟢	🟠	🟠	🟠	🟠
		Overcome regeneration barriers	Secure advance *Quercus* regeneration	🟢	🟢	🟠	🟠	🟠
		Reduce vulnerability by breeding, introduce new provenances, genetic modification		🟢	🟠	🟠	🔴	🔴
	Manage for resilience	Expand population (within range)	Emphasize *Quercus* spp. in afforestation	🟢	🟢	🟠	🟠	🟠
		Expand range		🔴	🟢	🔴	🔴	🔴
		Create refugia		🔴	🟢	🔴	🔴	🔴
Transformation	Novel ecosystems	Manage spontaneous ecosystems	Management of mixed plantings	🟠	🟠	🟠	🔴	🟠
		Create ecosystems	Translocate species	🟠	🟠	🟠	🔴	🟠
			Replace species within assemblages with desired functional traits	🟠	🟠	🟠	🔴	🟠
			Introduce exotics (non-native species) with desired functional traits	🟠	🟠	🟠	🔴	🟠

* Benefit criteria are M=Mitigation, A=Adaptation, D=Development, F=Food Security, W=Water supply or quality

🟢 In place 🟠 Partly in place 🔴 Not in place

Chapter 7
Conclusion

With an estimated 25 % of the global land surface in one way or another being degraded (FAO, 2010), and about 15 % considered appropriate for forest landscape restoration (Minnemeyer et al., 2011), the need for large-scale restoration to improve vital ecosystem functions and services has significantly increased in recent years. Action to conserve, sustainably manage, and restore forests can contribute to economic growth, poverty alleviation, rule of law, food security, climate resilience, and biodiversity conservation. It can help secure respect for the rights of forest dependent indigenous peoples, while promoting their participation and that of local communities in natural resources decision making.

This report addresses the contribution of forest and landscape restoration to climate change mitigation and adaptation. More specifically, the study draws on state-of-the-art scientific knowledge through case studies and a review of scientific literature and aims to demonstrate how restoration as both a socio-political process and technical interventions can help to meet climate objectives. In addition, this work is also intended to contribute to a better understanding of forest and landscape restoration among relevant decision-makers by means of a stoplight tool aiming at a simplified presentation of complex restoration initiatives, and how they may contribute to climate change mitigation and adaptation and vice-versa, in a specific local context.

7.1 Positive Aspects of Climate Change Mitigation and Adaptation in FLR

Reducing emissions from deforestation and increasing forest restoration will be extremely important in limiting global warming to 2°C. Forests represent one of the most cost-effective climate solutions available today (Parrotta et al., 2012). One of the major results of this study is the identification and detailed description of the many different ways in which FLR contributes to both mitigating climate effects and helping ecosystems and society to adapt to adverse effects of a changing climate. The contribution of forest and landscape restoration to climate change mitigation and adaptation consists of a wide array of policy, governance, and operational aspects that need to be addressed before a landscape can be improved to meet desired social, environmental, and economic objectives including those related to climate change.

Forest landscape restoration contributes to a number of current and emerging global and national policies of relevance to climate change. Already several global mechanisms exist to support concrete action towards climate change objectives (e.g., Bonn Challenge and FAO FLR Mechanism). Forest landscape restoration and climate-related policy are closely inter-linked: on the one hand, FLR can support achievement of climate-related commitments and on the other climate policies, tools, and funds can accelerate implementation of FLR. Existing global conventions, FLR policy initiatives, and support mechanisms clearly provide a comprehensive framework for action.

Fostering closer collaboration between the conventions around FLR with the aim to promote climate mitigation and adaptation can provide an effective means of accelerating national policy alignment and action not only for restoration and climate action, but also to achieve joint work under all three conventions. Indeed, FLR provides opportunities for synergies at various levels: among the conventions, on forest-related work, on climate-related work, and for Parties to optimise their work to meet commitments under several conventions.

The linkages among mitigation, forest adaptation, and social (community) adaptation exemplify linked socio-ecological systems. Linkages between local communities and forests are diverse and complex, mirroring the diversity of forest ecosystems and socio-political arrangements. Generally, community adaptations to climate change could affect forests positively by reducing pressures (e.g., clearing for agriculture, charcoal production, or escaped fires), improving forest management, and increasing protection by local enforcement.

7.1.1 Climate Change Mitigation and FLR

Mitigation takes aim at the causes of climate change, the emission of greenhouse gases (GHG) and their accumulation in the atmosphere; mitigation interventions either reduce the sources of, or enhance the sinks for greenhouse gases (GHG) (IPCC, 2003). Carbon conservation activities include policy reform to reduce deforestation drivers, conferring some form of protection status on existing forests (e.g., formally designated protected areas such as national parks or game management areas), and promoting sustainable forest management (including practices such as integrated wildfire management or reduced impact logging).

Carbon sequestration involves increasing forest area or the amount of carbon stocks per unit area. Forest area can be increased by passive (recolonization) or active means (e.g., farmer-assisted natural regeneration, agroforestry or afforestation). Purely mitigation objectives may tend to utilize fast growing species, although more adaptive options such as mixed-species plantings would provide biodiversity and other benefits without greatly reducing the amount of carbon storage. Activities include afforestation (conversion of non-forest areas to forest), reforestation (regenerating forests after logging or other disturbances), and restoration aimed at increasing productivity and diversity of degraded forests.

Mitigation activities such as afforestation may be situated on the landscape to improve connectivity among patches of intact forests, aiding dispersal, migration, and gene flow among populations of plants and animals. New forest areas including high-productive forests and plantations of native and/or non-native species around intact forests - especially protected areas - may act as buffers and reduce pressure on native forests as long as introduction of invasive species is avoided. Other mitigation actions such as production of biofuels, increasing efficiency of wood processing technology, or utilization of biofuels may reduce pressures on natural forests, thus enabling natural regeneration of forests. Substituting fossil fuel intensive products (e.g., steel, aluminum or concrete in construction) with wood products is a form of carbon offset. Additionally, wood products themselves provide long-term storage of carbon.

7.1.2 Climate Change Adaptation and FLR

Climate change adaptation may refer to the resistance and resilience of natural systems or the adaptive capacity of social systems (GIZ, 2014; FAO, 2013; Spittlehouse and Stewart, 2004). Forest adaptation measures are crucial to ensuring permanence of carbon fixed in mitigation forests (Galik and Jackson, 2009; Hurteau et al., 2008) and may increase carbon sequestration in native forests through improved forest management. Similarly, community adaptation activity such as conservation agriculture that increases crop yields may benefit carbon permanence in forests by reducing the need to expand cropped land to maintain sufficient food and in the process, increase carbon sequestered in cropland soil.

Adaptation activity in natural systems may seek to maintain forest area and carbon stocks within forests, maintain or improve other forest functions such as biodiversity habitat, or reduce vulnerability. Green infrastructure is a form of adaptation activity that provides direct or indirect protection from climate hazards. For example, planting coastal mangroves is a way to adapt to rising sea levels and protect from storm surges (Alongi, 2008; Gilman et al., 2008; Zhang et al., 2012). Biodiversity, hydrology, and rural economy are other important forest functions that can be improved in forest landscape restoration. Afforestation, reforestation, or agroforestry plantings using multiple overstory species or wide spacing to encourage colonization from intact forests can be implemented to increase biodiversity (Brockerhoff et al., 2008).

Diversity can be characterized as a resource as well as an essential outcome of restoration (Prabhu et al., 2015). Diversification is an important avenue for adaptation, emphasized by forces of global change whether environmental (climate) or economical (markets and trade), and for trees furthermore by virtue of their longevity. There is increasing evidence that higher biological diversity promotes ecosystem stability and productivity (Loreau et al., 2001; Cardinale et al., 2011; Hulvey et al., 2013; Zuppinger-Dingley et al., 2014) and provides value for tropical smallholders (Dawson et al., 2014a, 2014b). Clearly, there is value in increasing the investment in knowledge, and in conservation and use of diversity as an integral part of restoration (Graudal et al., 2014).

7.2 Challenges of Climate Change Mitigation and Adaptation in FLR

Commonalities exist among the factors necessary for achieving synergies in mitigation and adaptation in FLR, even though there is no single best approach that works in all socio-ecological contexts. Common factors include supportive policies and strategies, programs and projects, and institutional and financial arrangements. Successfully achieving large-scale landscape restoration is complex, however, and results may take a long time to become visible. Operationally, all of the best practices in forest management, agroforestry, and infrastructure and technology development can positively contribute to climate change mitigation and adaptation objectives in some way. However, the dearth of positive restoration examples render it difficult to convince decision-makers to work towards enabling legal and policy framework conditions and/or funding for larger-scale restoration initiatives. The complexity and inter-linkages of the ecological, economic, and social success factors as presented in this report explain why the effects of landscape restoration take a long time to become measurable on the ground. As experiences over the past decades have shown, reversing

Landscape planning by local community in Zambia. Planning in gender-specific groups produced alternative visions for restoration. Photos © John Stanturf

deforestation, for example, is hard to achieve because of the need to involve many sectors, actors, and decision-makers in order to address the drivers and underlying causes of clearing forests.

In many cases, local communities know why their landscape has been degraded (including the underlying causes). Usually, local stakeholders come up with a wide range of issues that need to be addressed to improve the socio-ecological system surrounding them. As a consequence, many different types of interventions and measures are usually recommended by stakeholders, in order to reverse land degradation. This is a good thing as it shows that years of promoting multi-stakeholder processes (which actually commenced much before the concept of FLR became fashionable) resulted in increased awareness by society about these problems and potential solutions. The bad news is that the solutions are rather complex, requiring many stakeholders to change from business as usual, necessitating large amount of funds and time. Mobilizing enough support and synchronizing stakeholders' actions with funding is a core issue. Setting priorities and staying focused on them is crucial, as is exercising patience until visible results emerge. The reality, however, is that projects often collapse after donor support is withdrawn unless steps are taken to secure sustainability.

One impediment to sustainability is that too often, secure tenure is lacking. Without secure tenure, local stakeholders have little incentive to long-term investments and commitment to long-term processes such as FLR. Meeting the livelihood needs of local forest users also contributes to long-term sustainability of FLR. A narrow focus on "forests" defined as closed canopy systems in FLR programs will undervalue the contribution of woodlands and trees outside forests to mitigation and adaptation goals and may also ignore the needs of local communities for food, fiber, and fuel from forests.

The challenges discussed so far exist under current climate; altered future climate will exacerbate these challenges and present new ones. For example, increasing competition for land for agriculture and other uses threatens sustainability of FLR unless accompanied by attention to meeting local needs for food security. Insufficient consideration of future climate means and extremes will negatively affect resilience of restored landscapes. Trade-offs may be necessary, such as between maximum carbon sequestration and landowner expectations for productivity of commercial species or enhancement of biodiversity. Not all landscape elements require closed canopy forests; agroforestry and trees on farms can meet mitigation objectives and landholder food security needs. In line with the objectives of FLR, native forests should not be converted to commercial plantations, whether for timber or food crops (IUCN and WRI, 2014), and biodiversity should not be damaged in undertaking forest restoration.

Overcoming these challenges and realizing the potential of FLR to contribute to climate change mitigation and adaptation will require informed, flexible responses from organizations and individuals. Unfortunately, technical capacity is at a low level in many countries where restoration potential is the highest, thereby limiting the consideration of climate-resilient interventions. Lack of local technical capacity means there is little opportunity to tailor restoration practices to local contexts (social as well as ecological) and approaches that have worked in other countries/cultures/political contexts (e.g., South Korea, US, Canada) are not necessarily appropriate to countries with different experience, e.g., of the rule of law. Central government agency staff, who should be partners in most projects to provide technical capacity, is frequently underfunded (if not complicit in corrupt practices). Often there is animosity between local stakeholders and agencies as a result of historical differences in approaches to land management and participation of locals.

The current emphasis on low-cost, non-intensive approaches to restoration (e.g., natural regeneration) may lead to failures when inappropriately applied in landscapes lacking, for example, seed sources within effective dispersal range or where grazing is not controlled. Even where appropriate controls may exist, necessary knowledge often is lacking of species' traits critical to their ability to adapt to future climatic conditions or even how to propagate a species and produce vigorous material for outplanting on restoration sites.

7.3 Improvements Needed to Enhance Understanding of FLR among Decision-makers

Given the necessary scale of investment globally to counteract centuries of degradation, multiple funding sources are required. The identification of specific ecosystem services and products (e.g., improved soil quality for increased productivity; enhanced water quantity and quality for human consumption; maintenance of biodiversity as basis for species conservation etc.) to be restored, paves the way for such large-scale investments. Potential benefits of restoration need to be identified and clearly communicated to and understood by decision-makers and society at large, so that concrete initiatives to transform a landscape can be implemented.

Given the urgency to restore deforested and degraded landscapes, combined with the immense benefits for climate change objectives that can be derived from forest and landscape restoration and taking into account the challenges faced in putting restoration into practice, a better understanding of FLR is needed. Because successful implementation of FLR depends on many motivated actors at different levels doing the right things, appropriate ways of promoting the understanding of FLR are needed including simple communication products, participatory planning, and joint evaluation of concrete landscape restoration initiatives in a given local context. In many cases, this requires a massive capacity building effort. With these ends and challenges in mind, we developed a "stoplight" tool for presenting the various FLR aspects and their relevance to climate change objectives. The stoplight tool presented in this report therefore aims to enhance this understanding of the complex mix of aspects and factors for successful implementation of FLR. It is intended to inspire and motivate potential actors to pursue FLR processes and activities.

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