Rehabilitating Degraded Forest Landscapes: a Technical Manual

Authors

Tefera Mengistu (PhD), MEFCC
Yigremachew Seyoum (PhD), MEFCC
Emiru Berhane (PhD), Mekelle University

Minstry of Environment, Forest and Climate Change (MEFCC)
Addis Ababa, Ethiopia, September, 2017

Acknowledgements

The authors would like to thank the Clinton Climate Initiative (CCI) for supporting this manual preparation. Special thanks to Ashebir Wondimu and the guidance provided by MEFCC leadership while preparing this manual.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CRGE	Climate Resilient Green Economy
FLR	Forest Landscape Restoration
GTP	Growth and Transformation Plan
MEFCC	Ministry of Environment, Forests and Climate Change
ANR	Assisted Natural Regeneration
A/R	Afforestation and Reforestation
SWC	Soil and Water Conservation
FAO	Food and Agricultural Orgganization
WRI	World Resource Institute
GoE	Government of Ethiopia
SDGs	Sustainable Development Goals
EFAP	Ethiopian Forestry Action Program

EXECUTIVE SUMMARY

Driven by unsustainable land use practices, adverse climatic conditions and population increase, land degradation is rampant and serious threat to human life by reducing provision of ecosystem services, food insecurity, and reduction in the ecosystem's resilience to natural climate variability.

Ethiopia has a large expanse of degraded lands suitable for forest restoration, providng huge opportunity for forest landscape restoration. The forest sector and forest landscape restoration has been receiving pronounced attention from the Government of Ethiopia, given the forest sector plays a central role in realizing the country's commitment to achieving a Climate Resilient Green Economy (CRGE). In addition to helping Ethiopia achieve environmental objectives, the forest landscape restoration can play an important role in contributing to economic growth.

At national level, there is huge gap between the wood product demand and supply. This has triggered unsustainable extraction of wood from forests and forest lands, and hence the degradation of forest landscapes. This degradation, often caused by deforestation, is a severe problem in Ethiopia, causing low agricultural productivity, food insecurity, and rural poverty. Such impacts of human activities on forests have been significant, with average annual deforestation rates estimated at 85,000 ha per year (GoV 2016) . Ethiopia's forests and forest landscapes are increasingly under increasing threat as the growing population requires more fuel wood and agricultural products. Unless action is taken to change the current path, an area of 9 million ha of land will be degraded until 2030 (CRGE 2011).

This manual aimed at collating the current state-of-knowledge about rehabilitation of degraded lands in Ethiopian landscape. The practice is found to be technically promising by using both the physical and biological measures. However, the practice so far lacks wholistic approach and goal oriented management. This manual assesses the need for forest landscape restoration (FLR), the technical gaps and proposes possible technical measures to be used as menu for selection based on landscape opportunities and challenges. Beyond the technical recommendations users are advised to consider local communities' participation, incorporation of traditional ecological knowledge, clear division of tasks and benefits, strengthening local institutions as crucial not only for cost-sharing, but also for sustainability of FLR. Evidently, science-based restoration of degraded land will occur only if science is strongly integrated into the decision-making processes.

CHAPTER 1: INTRODUCTION

1.1. Background

Land degradation can no longer be ignored as big challenge in many countries. That is why many countries are battling to overcome the challenges through rehabilitation of degraded landscapes. This challenge is highly linked to the challenges of poverty, drought and climate change. However, rehabilitation of degraded landscapes is considered to be vital to address increasing challenges of food security, poverty, climate change impacts and biodiversity losses. Though not adequate to reverse the trend of land degradation, various measures are being taken globally.

Various international commitments and regional implementation platforms are emerging around the world, including the AFR100 for Africa. The recent African Forest Landscape Restoration through the AFR100 initiative is one of the parallel efforts made at Pan-African level. This initiative is country-led effort to restore 100 million hectares of deforested and degraded landscapes across Africa by 2030. AFR100 is expected to accelerate restoration to enhance food security, increase climate change resilience and mitigation, and combat rural poverty. These global and regional initiatives are expected to directly contribute to the Sustainable Development Goals (SDGs) and the global climate agreement.

In the context of Ethiopia, a country with long history of settlement and agriculture, most of the central and northern highlands of the country have been cultivated for centuries providing subsistence for the rural community. Therefore, most of Ethiopia's rural landscapes are characterized by high rates of deforestation and land degradation making the extent and severity of land degradation in Ethiopia is unprecedented. Deforestation and land degradation is severe and has a long history in Ethiopia, especially in the central and northern highlands where subsistence farming and settlements have been changing landscapes for millennia. Major land-cover changes resulting from improper practices are taking place on the rugged topography that characterizes most of the Ethiopian highlands, which have accelerated land degradation and soil erosion. This has left vast areas severely degraded. This has left the country to lose fertile topsoil, estimated at 1 billion cubic meters (m3) per year, significantly reducing its agricultural productivity and threatening food security at household and national levels. Economic losses caused by the resulting soil degradation, for example, are estimated to be greater than $1 billion annually (Leonard Berry, 2003). Agricultural land expansion and high dependence on biomass energy are the two most important direct drivers of deforestation and forest degradation in Ethiopia (WBISP 2004, EDRI 2010).

Further, there is huge gap between the wood product demand and supply. This has triggered unsustainable extraction of wood from forests and forest lands, and hence the degradation of forest landscapes. This degradation, often caused by deforestation, is a severe problem in Ethiopia, causing low agricultural productivity, food insecurity, and rural poverty. Such impacts of human activities on forests have been significant, with average annual deforestation rates estimated at 85,000 ha per year (GoE 2016) . Ethiopia's forests and forest landscapes are increasingly under increasing threat as the growing population requires more fuel wood and agricultural products. Unless action is taken to change the current path, an area of 9 million ha of land will be degraded until 2030 (CRGE 2011).

An earlier estimate by FAO (FAO, 2010) put the degraded area on the highlands at 27 million ha, of which 14 million ha are very seriously eroded and 2 million ha of the seriously eroded lands have reached a point of no return. Recently, Ethiopia has made restoration opportunity mapping nationwide and this study indicates about 29million ha of land requiring restoration action (MEFCC and WRI, 2016), of which 11million requires immediate response.

Over the last decade, rehabilitation of degraded lands and degraded forests has become a priority in the country's development agenda. In its strategy document of December 2011, the Government of Ethiopia (GoE) identified the forestry sector as one of the pillars of the green economy that the country is planning to build by 2030 (CRGE, 2011). The government also set the following major targets for the forestry sector: afforestation on 2 million ha, reforestation on 1 million ha and improved management of 3 million ha of natural forests and woodlands. Through proper management of 5 million ha of forests and woodlands, Ethiopia hopes to achieve 50% of its total domestic greenhouse gas (GHG) emissions abatement potential by 2030. To this end, the country is engaged in various re-greening undertakings, and plans to scale-up good practices. Evidently, Ethiopia has traveled a long road to become the restoration leader in Africa and globally, a road not without difficulties. A growing population, which has created an increased demand for land for food production has led to the loss of many of its native habitats. This has created ripple effects throughout ecosystems, the economy, and communities. Over the past 30 years, Ethiopia began rehabilitating these extremely degraded lands by investing heavily in restoring hundreds of thousands of hectares of degraded and deforested land, improving agricultural productivity and enhancing livelihoods of the rural poor.

However, past efforts fall short of proper technical guideline and manuals that fits to prevailing local conditions. Further, improvement measures for the exiting restoration practices are critical to enhance the performance of the practices and support their scaling-up. Such manual serves as key input for developing a scaling-up strategy that is responsive to specific socio-economic and landscape conditions. This manual, therefore, provides a technical guide on the rehabilitation of degraded forest landscapes for effectiveness and implementation at scale. The manual will help to enhance the role of the forestry sector in building climate resilient green economy by 2030 as set in the strategic document. Thus the main objective of this document is to propose relevant forest landscape rehabilitation measures including their approaches and guide future rehabilitation efforts in the country.

1.2. Definition and facts of forest landscape restoration

A number of restoration initiatives have been implemented in Ethiopia, with variable success, and these are an important source of knowledge that could be used to improve future restoration efforts. Past rehabilitation efforts have key challenges that include technical and administrative challenges. On the other hand, many people living around degraded landscapes are locked in a vicious circle of poverty while at the same time these communities have wealth of knowledge and skills maintained for millennia. Climate variability exacerbated by climate change accelerated further degradation and challenged existing rehabilitation efforts. The vegetation degradation and fragmentation poses biodiversity loss making future restoration efforts even more difficult due to limited gene base. Challenges posed by climate change are expected to increase in the future. Climate change can potentially trigger faster rate of degradation and landscape impoverishment. Throughout this manual, the following definitions and contexts are used and readers are advised to first understand the contexts of these important terms.

Land degradation: a process in which the value of the biophysical environment is affected by a combination of human-induced processes acting upon the land. It is viewed as any change or disturbance to the land perceived to be deleterious or undesirable.

Exclosures: a method of rehabilitating land by protecting an area from the interference of animals and human encroachment for limited period of time, depending on site capacity and vegetation re-establishment.

Land Rehabilitation: the process of returning the land in a given area to some degree of its former state, after some process has resulted in its damage.

Land Restoration: Land restoration is the process of ecological restoration of a site to a natural landscape and habitat, safe for humans, wildlife, and plant communities. Land restoration is widely acknowledged as a way of reversing degradation processes and increasing the contributions of ecosystems and landscapes to livelihoods, land productivity, environmental services and the resilience of human and natural systems. The term “restoration” covers a wide range of conservation, sustainable management and active restoration practices that increase the quality and diversity of land resources, thus enhancing ecological integrity and human well-being.

Ecological restoration: is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed.

Management Plan: is the day-to-day operation of a defined site and administrative details and who is responsible for what after an assessment of its potential and any relevant threats.

Biological Rehabilitation Measures: a process of returning the land in a given area to some degree of its productivity through tree/grass planting and related bio-based efforts.

Physical Rehabilitation Measures: a process of returning the land in a given area to some degree of its productivity through structures involving bunds, terraces and basins.

Assisted Natural Regeneration: Assisted natural regeneration (ANR) is the human protection and preservation of natural tree seedlings in forested areas. In addition to protection efforts, new trees are planted when needed or required through enrichment planting.

Forest Landscape Restoration: addresses restoration at a landscape scale, often encompassing several ecosystems and land uses, as a way of enabling users to achieve trade-offs among conflicting interests and balancing social, cultural, economic and environmental benefits.

Functional Restoration: a planned process of restoration practice that focuses on restoration of ecological functionas and integerety of ecosystms in degraded landscapes.

Structural Restoration: a planned process of restoration practice that focuses on restoration of ecological components and landscape elements in degraded landscapes.

Passive Restoration: a restoration technique that involves less costly natural processes of regeneration such as exclosure and ANR.

Active Restoration: a restoration technique that involves more costly human induced restoration processes such as A/R and associated biophysical measures.

Community Participation: people's participation is defined as employing a method where the community is motivated to function and contribute as a group to perform various tasks starting from identification, selection and design of measures up to implementation and assessment of results.

Direct Seeding: is a regeneration method of sowing seeds of the required future trees directly on the ground

1.3. Why the manual is needed

The main objective of this manual is to propose relevant forest landscape rehabilitation measures including their approaches and eventually guide future rehabilitation efforts in Ethiopia. This manual, therefore, provides a technical guide on the rehabilitation of degraded forest landscapes for effectiveness and implementation at scale. The manual will help to enhance the role of the forestry sector in building climate resilient green economy by 2030 as set in the strategic document.

1.4. Targeted users of the manual

The manual is designed for natural-resource policymakers and other decision-makers at different levels, regional agencies of forestry, private land owners, rural development experts at various levels, and managers of forest restoration programmes and initiatives in degraded forest lands; restoration practitioners, bilateral and multilateral development agencies. The manual should be considerd as framework document to be adopted based on local conditions and circumstances.

1.5. How to use this manual

This manual has six chapters in addition to the introduction. Chapter 2 sets out the need to restore degraded forest landscapes. Chapter 3 describes activities prior to rehabilitation efforts. This ranges from baseline establishment to setting bylaws and species identification for decision-makers and practitioners. Chapter 4 presents guidelines for practitioners for on-the-ground activities. This includes guide for both physical and biological measures, providing guidance on planning and implementing restoration, including restoration strategies; management planning; and planting. Possible actions and recommendations are proposed for implementation and effective restoration efforts in forest landscapes. Chapter 5 describes other key aspects including free grazing, value addition and marketing and benefit sharing mechanisms. Chapter 6 describes the monitoring and evaluation of forest landscape restoration initiatives. Among other things, it describes the Monitoring and Reporting Tool for Forest and Landscape Restoration. For example, a monitoring and evaluation plan should be developed during the rehabilitation planning phase and implemented throughout the life of the rehabilitation initiative. The end materials include a glossary of the key species to be considered while implementing this guideline.

CHAPTER 2: WHY REHABILITATING DEGRADED FOREST LANDSCAPES?

2.1. The need for rehabilitation of Forest lands

Ethiopia is a country with long history of settlement and agriculture. Most of the central and northern highlands of the country have been cultivated for centuries providing subsistence for the rural community. Evidences suggest that more than 80% of the livelihoods of the current population of the country is dependent on agriculture. The long history of crop and livestock production coupled with increasing population and livestock pressure has inflicted immense pressure on the natural resource base of the country. Vegetation cover, soil and water resources have been lost rapidly, gradually diminishing the ecosystem services provided by the rural landscapes. Till recently, lack of appropriate policy and institutional setups that provide an overall guidance towards ensuring the sustainability of crop and animal production and maintaining the natural asset were the key drivers that aggravate landscape degradation in Ethiopia. As a result, deforestation, forest degradation, soil erosion, desertification and loss of biodiversity have been prevalent environmental problems of Ethiopia. These environmental problems brought about natural calamities such as drought, flood and disease and pest incidences resulting in loss of agricultural productivity, famine, poverty and migration.

Land and forest degradation are critical environmental problems threatening the survival of Ethiopian's because vital environmental disasters such as floods, drought, desertification, soil erosion are connected with the extent of forest exploitation and destruction. Among others, the severity of Ethiopia's land degradation is expressed by billions of tons of soils annually lost from agricultural landscapes. Despite the variations in magnitude, trends exhibited by different studies confirm a huge annual loss of productive top soil. According to a report by EFAP (1994), 1.9 billion tons of soil and an average of 42 tons ha-1, is eroded annually from the highlands of Ethiopia. The loss of the soil resources is accompanied by loss of other vital resources such as nutrients, water and agro biodiversity (Paulos, 2001). The land area vulnerable to soil erosion caused land degradation is substantial. Lemenih (2004) reported that over 50% of the agricultural land in the highlands of Ethiopia is already severely affected by soil erosion. In addition to, the loss of the productive capacity of the arable land, soil erosion converts farming and grazing lands into deep gullies further exacerbating the land shortage caused by the population growth.

The loss of the natural forests and woodlands through deforestation and selective cutting is the key factor that causes forest landscape degradation. Land and forest degradation can directly contribute to poverty by reducing the availability of other valuable goods and services important to poor households such as fuel wood, construction materials, wild foods, and medicinal plants (Gashaw et al., 2014). Among others, land degradation is the key reason for low and declining agricultural productivity resulting in food insecurity and rural poverty in Ethiopia (IFPRI, 2005). Land degradation reduced livestock productivity as a result of reduced grazing resources, loss of nutritious plants and grass species (Fitsum et al., 1999). Loss of ecosystem services due to land degradation adversely affects the health, well-being and livelihood opportunities of the individuals (Gashaw et al., 2014). Therefore, re-greening degraded landscapes is a necessity for communities whose livelihood merely depend on the natural resource base and vulnerable to climate change shocks.

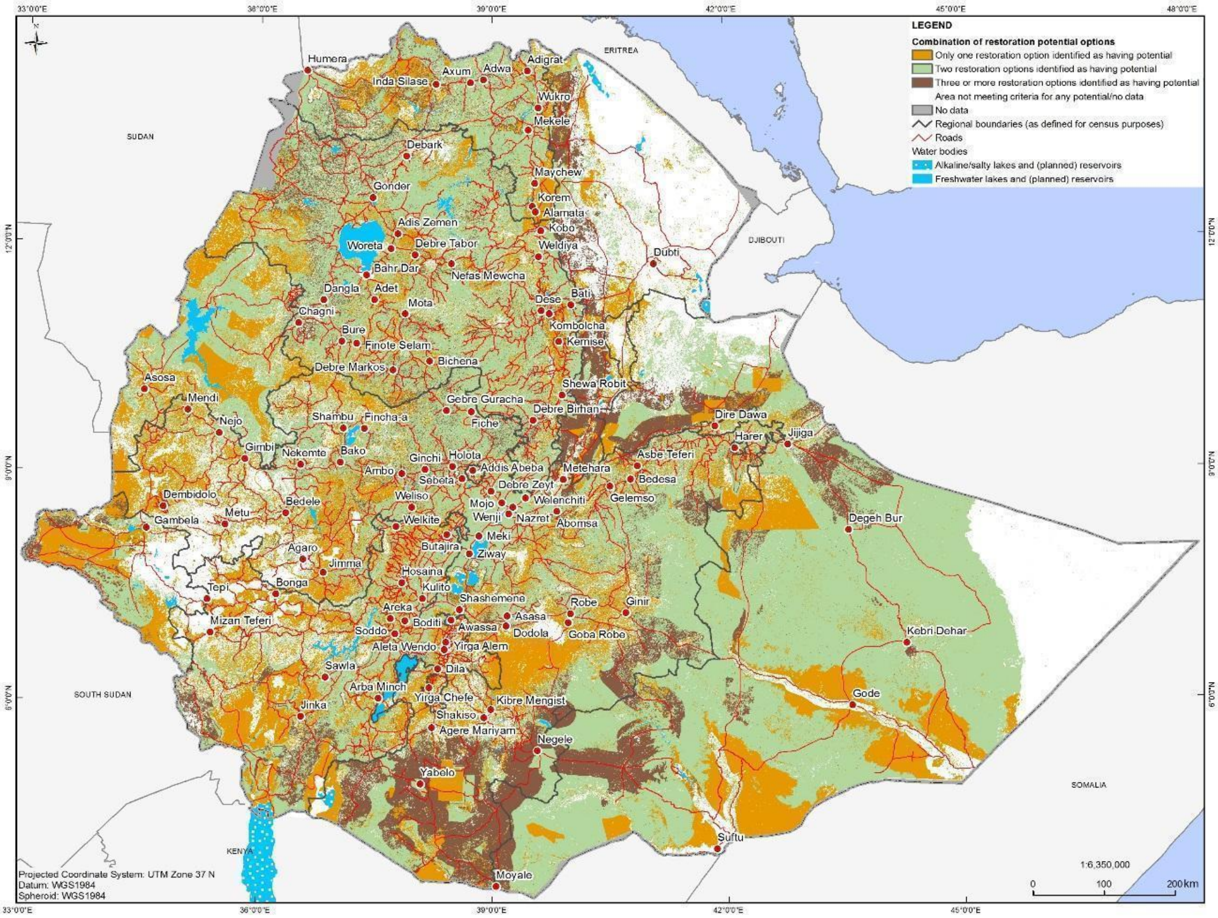

Figure 1: Overall potential for tree-based landscape restoration

Source: MEFCC/WRI National Potential and Priority Maps for Tree-Based Landscape Restoration in Ethiopia. DRAFT Version 1.0, 30 September 2016.

2.2 Existing trends of rehabilitation in Ethiopia

To circumvent problems of land and forest degradation, efforts have been exerted to rehabilitate degraded forest landscapes through physical and biological measures (Horne, 1993; Tekle, 1999; Badeg, 2001; Delahunt, 2006). The major physical measures implemented in degraded communal lands include construction of bunds, check dams, micro-basins and hillside terraces. Likewise, biological measures that include afforestation and re-afforestation in farmlands, around homesteads, degraded communal lands, and exclosures have also been implemented (Badeg, 2001; Foil et al., 2002; Mekuria et al., 2011).

Ethiopia has been implementing different types of soil and water conservation activities and capacity building programs since 1980s (Tekle, 1999). The objectives of the interventions were to reduce soil erosion, restore soil fertility, improve micro-climate, agricultural production and productivity (Mekuria et al., 2007). These interventions were initiated with the support of aid agencies through food for work programs (Tekle, 1999; Badeg, 2001). The activities were implemented through food for work program in drought affected areas with mass campaigns. These interventions were backed by research findings obtained from six research sites that represent different agro-climate, soil, geomorphologic and farming practices in Ethiopia (Shivered and Holden, 1999). The soil and water conservation practices brought impressive results in quantitative terms (Yeraswork, 2000). Overall, around 800,000 km of soil and stone bunds on croplands and 600,000 km of hillside terraces were constructed, and some 100,000 ha of land was closed for natural regeneration through the Food for Work program (Horne, 1988).

Biological rehabilitation measures include different forms of tree planting. The use of tree plantations to foster ecosystems to reestablish native woody species, native fauna and soil fertility has been described as restoration (Lemenih, 2004). Tree planting as a means of re-greening degraded forest landscapes has long been exercised in Ethiopia. Historical records reveal that tree planting has begun as early as 1400s by the order of King Zera-Yakob (1434-1468). The practice of modern plantation, however, was started by Emperor Menelik II (1888-1892) in 1895 by introducing 15 eucalyptus species as well as Acacia and Pine species which were imported from Italy, Portugal, Australia and Greece (Bekele, 2003). Emperor Menelik II introduced different fast growing exotic tree species in response to the prevailing deforestation and the shortcomings of forest products in major towns of the country. Consequently, there were various attempts made to re-green degraded forest landscapes during the Derg and the present regimes. Various forms of reforestation/afforestation, area exclosure, and woodlot development are popular tree based rehabilitation strategies observed today (Teketay et al. 2010).

Exclosure involves protecting areas mainly through social fencing from any form of cultivation, cutting trees and shrubs, or grazing by livestock (Lemenih and Kassa, 2014). Exclosures has been recognized as the most important measures taken to rehabilitate degraded lands in Ethiopia (Mengistu et al., 2005; SCIP, 2014). This practice has become very common, due to the impressive improvement observed in productivity and reduction of soil erosion. Furthermore, it is the cheapest and fastest degraded land rehabilitation mechanism (Birhane et al., 2006). Hence, exclosures has been widely practiced in different parts of the country. Areas put under exclosure are increasing from time to time and the total area under exclosure in Amhara and Tigray Regional States alone were about 3.09 million ha in 2013 (Lemenih and Kassa, 2014). Rehabilitation of degraded land and forest through area exclosures is the priority at the current natural resource management agenda of the country.

Figure 2. Some practices of exclosure in degraded lands of Ethiopia

Assisted natural re-generation combines closing degraded sites from livestock and human interference with other management interventions that enhance the regeneration process. Management interventions such as planting of seedlings (exotic or indigenous species), aerial seeding and construction of soil and water conservation structures used to speed up succession through the modification of microclimatic and soil conditions provided to closed sites (Lemenih and kassa, 2014). The tree species planted include *Acacia saligna* (Labill.) H. L. Wendl., *Grevillea robusta* A. Cunn. Ex R. Br., *Eucalyptus globulus* Labill. *Cordia africana* Lam. and *Casuarina equistifolia*. R. and G. Forster (Yirdaw et al., 2014). primary forest species (Knowles and Parrotta, 1995), and the framework species method (Shono et al., 2007) are some of the planting approaches that show promising results. Numerous studies have also demonstrated the catalytic effect of commercial tree plantations in fostering the regeneration of native forest species in the understory (Parrotta et al., 1997; Senbeta et al., 2002).

Small-scale plantations are getting momentum since the last one and half decade (Lemenih, 2010). While the total plantation forests in Ethiopia are estimated to cover between 900,000-1,000,000 ha of land, small scale plantations account for 85% of the total. The major drivers for the expansion of smallholder plantations are income generation from tree products and self-sustenance in meeting household energy demands. According to the review by Lemenih (2011), the major reasons that are initiating the smallholder farmers in Ethiopia to expand and establish smallholder plantation are scarcity of fuel and construction wood and the resulting demand in the nearby markets. In some communities, eucalypt plantations are regarded as insurance resource or life savior, since they are cut and readily converted to cash during critical needs (Negash, 2002). The economic incentive of small scale plantations is significant in the rural households of Ethiopia motivating further expansions. The contribution of sales of products from small scale eucalyptus plantations to the average household income was estimated as 25% which increases to 72% for the poor households (Lemenih and Kassa, 2014). The income from trees and related products has become the third most important source of household income in some parts of the Amhara Regional State (Sandewall et al., 2015). The return that can be secured from small scale plantation offers lucrative household level investment opportunities. Tree farming by private farm households and entrepreneurs is a growing area of small investment throughout rural and urban Ethiopia (Lemenih, 2010).

2.3 Criteria and indicators for rehabilitated forest lands

Setting criteria and indicators is crucial to monitor and evaluate progress and final impacts of rehabilitated forest lands. Criteria and indictors for biophysical and socio economic attributes of rehabilitated forest landscapes should be identified in close consultation with pertinent stakeholders during project design phase. Biophysical criteria such as vegetation cover, diversity, soil productivity, and environmental calamities can be employed to monitor progress and evaluate impact. Indicators such as biomass, flora and fauna species richness, nutrient availability and risk of drought and flood are some of the respective indicators. Socioeconomic criteria such as household income, job opportunities, and attitude are commonly practiced. Indicators for the socioeconomic criteria include annual income, people with jobs and the communities' view of rehabilitation as positive or negative.

2.4 Anticipated Products and Services

Rehabilitating degraded landscapes in a mountainous country such as Ethiopia brings significant ecological, economic and social impacts. Rehabilitated forest landscapes provide various wood and non-wood products. Forests and the benefits they provide in the form of wood, food, income, and watershed protection have an important and critical role in enabling people to secure a stable and adequate food supply. Besides their direct contribution to the national economy through wood and non-wood products, the forest resources contribute significantly to various sectors such as energy, water, agriculture, tourism and health.

Forests and woodlands are source of fuel for the large majority of the rural community of Ethiopia. Ecological services of rehabilitated forest lands include forests role of serving as habitat for wild fauna and flora. These resources serve as useful source of ecotourism, medicine, food and household income. Ecological services of rehabilitated forestlands are vital for the wellbeing of the environment and human survival. Rehabilitated forest ecosystems provide important services such as carbon sequestration, water flow, erosion control, tourism, maintaining biodiversity, harboring medicinal and edible plants etc. Ethiopia has a great potential of benefiting from carbon finance with sustainable management of existing vegetation resources and future afforestation and re-afforestation programs that enhance carbon stock.

The Net Present Value of exclosures ecosystem services was found higher than alternative agricultural production indicating that exclosures are competitive to alternative land uses (Woldie Mekuria, 2013). The following figure shows differences in ecosystem carbon stocks between paired exclosures and adjacent communal grazing lands in relation to exclosure age (P<0.05).

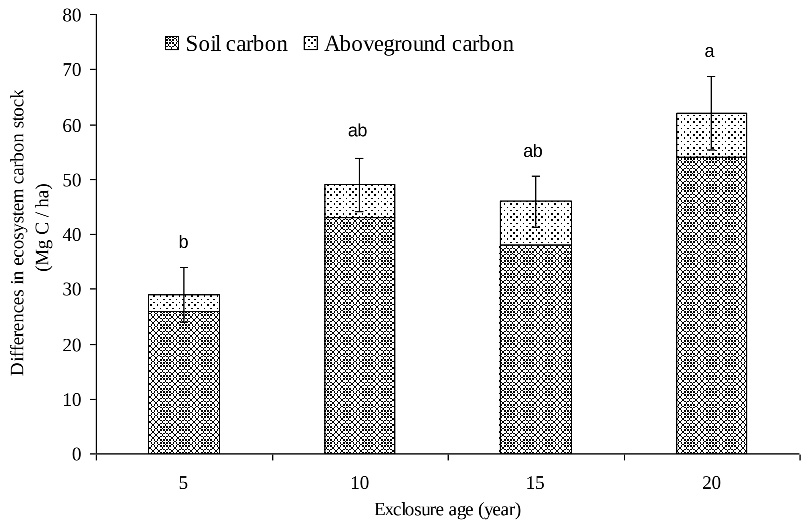

Figure 3. Differences in ecosystem carbon stocks between exclosures and adjacent grazing lands (Woldie 2013).

Control of the flow of water through various sources such as lakes, rivers, streams and the groundwater is an important regulatory function of forested landscapes. Regulated water flow guarantees sustained supply of water to downstream irrigation initiatives contributing to household food security. The regular supply of water has significant socioeconomic contribution to day-to-day lives of human and livestock residing in the downstream. Trees and other vegetation in forests hold the soil through their root networks and prevent soil erosion. On slopped terrain, the root system of trees helps hold soil in place, reducing the chance of landslides and overall soil loss. Soil erosion reduces land productivity by washing away important nutrients such as nitrogen, phosphorous, potassium and other vital nutrients essential to soil fertility. Soils that have lost important nutrients may show yield decline of 10-30% (Pimentel et al., 1995) indicating the economic implications of managing forests for protection of soil erosion. These roles can only be maintained through well protected and managed forests in the upper catchments.

CHAPTER 3: ACTIVITIES PRIOR TO REHABILITATION OF DEGRADED FOREST LANDSCAPES

Successful forest landscape restoration required a landscape approach that takes in to account the existing socio-economic and landscape conditions and the interactions between the two. Furthermore, degraded landscape restoration should focus on functional restoration rather that structural restoration. Rehabilitation of degraded lands at landscape level should include animal husbandry, agroforestry and farmlands.

At the habitat level, the rehabilitation technique for degraded lands should be site-specific. The rehabilitation technique developed for moister areas may not be the best suited for dry areas and vice versa. Depending on the site conditions and the objectives either a single or combinations of different rehabilitation methods can be utilized. However, passive restoration (e.g. exclosure and assisted natural regeneration) is usually suggested when the natural potential is not fully affected by the level of degradation. On the other hand, highly degraded a landscape require active restoration approaches including afforestation/reforestation of framework and nurse species that are native to the sites and adapted to local environmental conditions.

3.1. Site selection and mapping

Selecting sites, mapping and priorities for restoration of degraded lands requires multi-stakeholder approach. This demands mapping different land uses, identifying land use challenges and opportunities. What is recommended is to make the mapping exercise participatory with local stakeholders. Participatory mapping promotes interaction and helps visualize the `mental map’ of communities. Using maps makes it easy to indicate resource availability, to assess infrastructures and access, and even to identify wealth/social groups and relationships. It also stimulates discussion and debate.

Land use challenges are defined as problems arising from the way land is used and/or managed. Based on how socioeconomic factors (e.g., increase in population density, land tenure, shifting cultivation, lack of land use planning and policy) as well as environmental factors (e.g., changes in climatic patterns, availability of rainfall, wildlife habitat) affect the way land is used and managed. The land use challenges usually act as roadblocks to achieving local and national economic, social, and environmental opportunities. Such land uses should be selected and prioritized based on the socio-economic and environmental demands.

Global data sets can be used to map sites when local data sets is not available. The results of the whole exercise should provide an overview of potential restoration opportunities across landscapes in order to inform discussions and help start a dialogue on how best to proceed with landscape restoration activities. Once a potential restoration area has been identified, a local-level assessment and community consultations need to be carried out to ensure that planned activities are aligned with local level objectives.

3.2. Establishing baseline

Baseline information provides the benchmark against which the progress of the restoration plan can be measured. Establishing baseline is important to measure progress and impacts of rehabilitation efforts. However, setting criteria and indicators is crucial to monitor and evaluate progress and final impacts of rehabilitated lands. Baseline should be established for both biophysical and socio economic attributes. Biophysical baseline includes assessment on vegetation cover, diversity, soil productivity, and other environmental conditions to monitor progress and evaluate impact. Indicators such as biomass, flora and fauna species richness, nutrient availability and risk of drought and flood are some of the respective indicators. Socioeconomic baseline includes assessment of household income, job opportunities, and attitude of people. Indicators for the socioeconomic criteria include annual income, people with jobs and the communities' view of rehabilitation and land degradation.

Once assessment criteria and implementation standard is developed for each of the landscape elements and restoration options selected, spatial analysis and mapping will be conducted to establish baseline against which results will be compared later. Before beginning a baseline survey, a series of decisions should be made on types of baseline data, sampling method, total sample size and on general socio-economic conditions.

3.3. Species-site visa-vis species-purpose matching

One of the challenges for the lack of success in tree planting is the limitation in species site matching. Species selection should be conducted carefully in order to ensure success. Each site condition requires the most suitable species available or mixture of species. Site to be restored through rehabilitation and their level of degeradation. Species for improvement of site conditions may not be useful for productivity or otherwise. Therefore, species selection should take species attributes such as nitrogen fixing, growth rates, soil fertility improvement, allelopathy, productivity etc. Based upon the different site conditions (soil texture, reaction, fertility, land use, and others) and objectives set initially, one has to select the most suitable species or combination of species for an area. Species selection should also take into account the moisture and climatic conditions of the rehabilitation sites. More drought tolerant species and provenances should be planted in moisture deficit areas. Likewise, species that can grow under marginal soil condition should be planted in shallow, infertile and degraded sites.

3.4. Enhancing Community and stakeholder participation

Landscapes transcend political and jurisdictional boundaries, often times encompassing many different land uses and actors. Moreover, the involvement of a wide range of stakeholders is essential for any FLR to be successful. To this end, participatory planning and designing of FLR with stakeholders is a requirement. Therefore, rehabilitation of degraded lands calls for concerted rehabilitation efforts, involving several stakeholders, both governmental and non-governmental with clear division of tasks, rights, costs and benefits. Particularly, local communities who are affected most by land degradation require end-to end participation. Such level of participation is crucial for sustainability and utilization of local knowledge. Further, rehabilitation of degraded lands need to fit in to the local needs and requirements. Utilizing traditional knowledge system in restoration practices provides ample opportunities relevant to restoration ecology, such as setting reference ecosystem, utilizing traditional land management practices, and species selection for restoration planting. On the other hand, local communities are key in providing guidance on analysis of landscape challenges and results.

Another policy-related factor that influences the success of rehabilitation is well-defined land tenure and/or secure property rights for land and trees (Muys et al. 2006).

3.5. Designing and setting by-laws

Experiences of rehabilitation efforts so far show that there are customary laws (Bylaws) that have contributed to the success. Such bylaws play significant role in the successes of community-based natural resources managements in many countries. However, most bylaws are largely tuned to penalize wrong doers, and less to reward achievements. For effectiveness and sustainability, bylaws should balance between conservation and utilization objectives. The balance between conservation and utilization solves the existing challenge with regard to punitive bylaw orientation. However, the bylaws for a particular practice should be closely aligned with the objectives set at the outset. The adoption of a signle generic bylaws, which are often punitive, for many landscapes has to be avoided and bylaws have to be aligned with the initial goal. The bylaws set for the establishment and management of rehabilitation efforts should be acknowledged by the judiciary for better enforcement.

3.6. Setting and designing the management plan

Any practice requires initial plan. Designing management paln is also relevant for rehabilitation of degraded lands. Objective-based management of degraded lands is important for both environmental objectives and livelihood support. At landscape level, creating buffer areas around rehabalitated lands, excluding cattle interference and reducing intensity of wood harvest are possible landscape management activities.

As the soil seed bank has limited woody species, natural regeneration from soil seed banks can only play minimal role (Kebrome and Tesfayem 2000; Tefera et al. 2005; Emiru et al. 2002, Wassie et al. 2009) in restoration. Therefore, natural woody species recovery will primarily depend on presence of seed trees in the vicinity and successful seed dispersal mechanisms. As native species in the vicinity facilitate the regeneration of woody species, maintaining propagule pool for exclosures and facilitating germplasm flow will ultimately sustain exclosures and help to restore the whole landscape (Wassie 2009, Yirdaw 2002). This underlines the importance of sustainable management of the few remaining forest relics and relic trees around degraded lands. Rehabilitation efforts established nearby natural relics quickly develop rich understory indicating the importance of natural propagule pool to donate seeds. Therefore, prompt and strict protection of the scattered remnant forests is very important for the successful future restoration ventures.

Designing management plan for landscape restoration emphasizes the importance of using a holistic approach. It should focus on integrated resource management, land resources and natural disturbance regime zoning. The complexity involved in managing a degraded ecosystem for wildlife habitat, water quality, timber, and biodiversity can be overwhelming and difficult.

Desiging management plan for rehabilitation site require apriori historic research undertaking, field data collection, and analysis of existing plans and research in order to identify the underlying causes of degradation, characterize the current condition of the ecosystems, and identify solutions that would restore ecological structure (physical features), composition (species assemblages), and function (biological, hydrologic, chemical) where it has been degraded or lost. The field assessment may include;

1. Environmental Conditions and Settings: Landscape and physical components affecting ecosystem processes, e.g., flooding regime, site hydrology, soil type and conditions, and surrounding land use.

2. Ecosystem Structure: Summary of physical structure of ecosystems, e.g., closed canopy forest, forest with canopy gaps, open canopy forest, early successional forest, shrub/scrub and grassland including other landuses.

3. Vegetation Inventory and Relative Density: Dominant species present within ecological communities and relative densities across landscape unit area (densities of native, exotic, and invasive species using vegetation assessment methodology

4. Ecological Influences: Human or naturally induced ecological influences appearing to have a substantial effect on ecosystem processes: e.g., land use history, known/existing disturbance, type/extent of invasive species, animal use evidence, environmental conditions.

Finally, the management plan should have clear purpose and objective. Each of the objectives set will have priority target area of intervention.

In order to identify and prioritize restoration need or target area, we need to identify management units. These units may be delineated based on several factors, such as geographic size/location, landscape influences or physiognomy.

Evident based evaluation of rehabilitation success as per the management plan should follow adaptive assessment process. However, the minimal elements of any truly adaptive management plan include (1) revising restoration goals and expectations with emerging opportunities (2) a sound conceptualization of the systems and interactions, (3) an effective process for learning from past management actions, and (4) explicit feedback mechanisms for refining and improving management based on the learning process.

CHAPTER 4. TYPES OF REHABILITATION MEASURES

4.1. Physical rehabilitation measures

Degradation of dry forests is often accompanied by depletion of soil fertility to support good growth of trees. Thus, site amendment measure should be done first to benefit successful rehabilitation of severely degraded sites.

In Ethiopia, various efforts have been exerted to rehabilitate degraded forest landscapes through physical and biological measures (Horne, 1993; Tekle, 1999; Badeg, 2001; Delahunt, 2006). The major physical measures implemented in degraded lands include construction of bunds, check dams, micro-basins, hillside terraces and other moisture harvesting structures. The physical measures are mainly for soil and water conservation activities targeted to reduce soil erosion, restore soil fertility, and conserve moisture. These interventions were initiated with the support of aid agencies through food for work programs (Tekle, 1999; Badeg, 2001). Detailed description fo the different physical measures for different environmental condition is listed in '*Community-based Participatory Watershed Development Guideline* (MoARD 2005).

4.2. Biological rehabilitation Measures

4.2.1. Exclosures; Establishment and Management Techniques

Exclosures refers to areas protected from human and animal interference by using a social fence. Such areas are left from heavy human interference to help them regenerate mainly through natural process. The practices associated within exclosures mainly should encourage natural process while incorporating options that are well accepted by the local people based on the observed and perceived economic and ecological impacts. Thus, participatory approach should be considered as a starting phase.

The exclosure technology can be easily scaled up to many sites as component of land-scape re-greening activities. Commonly, exclosures should get due concern to rehabilitate and develop upper catchments of main upper watersheds. Moreover, upper catchments of lakes and irrigation dams hould be protected and restored through exclosures.

Exclosures are best interventions to prevent areas prone to landslide. However, as deemed necessary, the exclosure practice can be extended to degraded farmlands which are abandoned from being farmed. There are also extensive grazing lands that could be restored and rehabilitated through exclosure. Areas that are abandoned as a result of mining, irrigation, road construction, commercial farming/plantations,etc. could be set aside as exclosures to effectively restore and gradually convert to productive sites. Exclosures should be promoted to create job to the youth in the rural areas where there is high population density such as in the highlands of Ethiopia. The technology can be applied in a wide range of ecological conditions and surcumstances and requires less labor input. With a proper management plan geared towards achieving an intended objective, the exclosure technology can be extended to any area where deforestation and land degradation is a problem.

4.2.2. Assisted Natural Regeneration (ANR)-Establishment and Management Techniques

Assisted Natural Regeneration (ANR) is a simple, inexpensive and effective technique for converting degraded areas to more productive lands (Ganz and Durst, 2003). The key elements of ANR are controlling fire, restricting grazing, suppress growth of economically non-viable species and involve local people. The benefits of ANR are fundamental, highly diverse biologically and there are substantial benefits for local people. Over the past decade, scattered efforts have been made in Ethiopia to develop and apply ANR approaches to restoration. It becomes now apparent that there are additional opportunities to diversify strategies and expand restoration work through the application of ANR. In fact, few efforts have been made to promote ANR throughout the country. Given the low cost and numerous benefits from ANR, it would seem logical that ANR be accepted and applied broadly in the country.

ANR is very compatible with traditional systems of natural resource management. Therefore, a clear examination of community approaches to the management of native plant communities is necessary to promote ANR at larger scales. This could serve as the basis for clarifying objectives and concrete actions to restore native plant communities and ecosystems using ANR approaches. It is essential that constructive partnerships be formed among NGOs, governments, the private sector and communities to design effective ANR approaches that fits in to local conditions, which will have mutual long-term gains for all stakeholders.

The advantages of ANR or similar strategies in degraded land rehabilitation can be summarized as:

- faster and cheaper (it may not be necessary to establish a nursery);
- involves minimum disturbance and promotes biodiversity conservation;
- maintains the original vegetation stand and corresponding ecosystem functions;
- promotes people empowerment and use of local knowledge;

This manual presents a short overview of the selected approaches to advance ANR in Ethiopian landscapes.

Direct seeding

Afforestation/Reforestation as a national, regional or global task is not easy to achieve, as shown by past experiences. It can be expensive, ineffective and even a constraint to enhancing biodiversity, depending on how it is implemented on the ground. Thus, there is a need to look for options which will effectively and efficiently bring back ecosystems, with much of its original characteristics and functions of productivity, stability and sustainability. Direct seeding of seeds of known genetic base is one of the ANR approaches to foster rehabilitation, limit cost and enhance biodiversity.

Direct seeding is a regeneration method of sowing seeds of the required future trees directly on the ground for rehabilitation, reforestation, afforestation or agroforestry (Peter 2001) purposes. In this way the laborious task of raising nursery plants and transplanting them to the planting site is omitted. Direct seeding offers various interesting possibilities e.g. the ability to rapidly increase the area being forested or the ability to provide rural people with an inexpensive method to obtain benefits from trees.

Direct seeding has over the last 50 years gained importance, especially in North America and China where large areas have been direct seeded from helicopters or aeroplanes. Direct seeding from the air has been widely used in China where more than 15 million ha have been reforested between 1956 and 1985 (Xinhua & Jingchun, 1988).

Unlike the favorable climate in the tropics, direct seeding is less reported compared with the subtropics or the temperate regions. Trials have been carried out and reported from various tropical countries for example Indonesia, Philippines, India, and the Sahel in Africa. Direct seeding in the tropics has been carried out many times without the results ever being published.

In the dry tropics conventional forest plantation is limited and hence direct seeding can play an important role in afforestation and reforestation programs. Therefore, direct seeding has the ability to contribute significantly to tropical forestry in the future, probably not as the main regeneration method but as a method that under certain circumstances is superior to other methods. The following will describe various scenarios where direct seeding is employed in the tropics.

Direct seeding can be applied for rehabilitation sites, agroforestry systems, plantation sites, mining sites and inaccessible sites. Although any desired species can be, species of Seeds of trees, often exotic legumes are preferred for their nitrogen fixing and fast growing habits.

In Ethiopia, the success of rehabilitating degraded lands through exclosures, which resulted in a dense regrowth after reducing human/livestock pressures appeared from soil seedbanks and old stumps. This success is a very good indicator for the potential of direct seeding where ever it is appropriate.

Advantages or disadvantages of direct seeding

Advantages of direct seeding

- Establishment cost is low as there are no nursery and planting expenses.
- Transport is much cheaper.
- Better root development and avoidance of transplanting shock, which is common for nursery-raised seedlings that are transplanted from the sheltered nursery to the harsh environment of the planting site.
- Species can even enrich the soil if N-fixing legumes are used
- Large areas or inaccessible areas such as hilltops, mudflats or swamps can be seeded.

Disadvantages of direct seeding

- Normally more seed is required to stock an area sufficiently, mainly because seeds are lost to seed-predators or erosion. These losses are enhanced if the seeds are broadcast sown on the surface. Several studies have shown much less predation if the seeds are covered even lightly with soil.
- Weeds can certainly be a big problem, and will require weeding.
- Tree density is more difficult to control. Too high may require early thinning, whereas too low density may require additional seeding or planting.

Methods and techniques of direct seeding

Site preparation

Site preparation will depend on previous use of the area and the method of sowing. A dense cover of weeds can prevent the seed from coming in contact with the soil or prevent proper seedling growth, therefore preferably, weeds should be removed before sowing. Site clearing are options that increase efficiency. Otherwise, residues can persist long enough in the soil to harm germination and growth of seeds and seedlings. Weeds can be controlled either in strips or randomly encompassing the whole area. The socalled seed-spots are normally prepared with a hoe, which after clearing the ground can create fertile ground for seeds to germinate and grow.

Manual seedspot preparation and hand sowing is the method that gives the best results, but is on the other hand the most labour intensive method. Instead of preparing the whole site, only seedspots are prepared and sown, normally in one operation. Seedspots are placed 2-3 meters apart and measure about 30 cm by 30 cm depending on existing weed-cover. The seedspots are prepared with a hoe and the seeds are placed either on top or in the ground at a depth depending on the type and size of the seeds (Peter 2001; Mann & Derr 1964). Smaller seeds require smaller depth and bigger seeds require deeper soil. Often a few seeds are placed in the same seedspot to ensure at least one plant per seedspot; the amount of seed will depend on viability and expected survival.

Sowing the seeds

Seeds can be sown or placed more exactly in the ground where it is expected to grow by hand. Sowing can be done in rows or in a scattered pattern with the required species. Row seeding will place the seeds with a certain spacing, and most importantly, place them in the soil; the seeds are thereby better protected from predators and have better conditions for germination and survival. Scattering seeds on top of the ground is generally termed as 'broadcasting'. Broadcast of seeds normally requires more seed because seeds are lost to predators, are washed away by rain or they fail to reach a proper germination site. Large areas can be broadcasted in a short time. For ease of germination and improving success, seeds can be mixed with water (hydro-seeding) and mulch where the added mulch will provide an initial seed cover as well as retaining moisture.

If the species in question have not grown on the site previously, it is recommended to supply a small amount of soil with each seed. The soil can be collected from the place where the seed was harvested, or from a nearby site where the species grow. The application of soil is to ensure that symbiotic micro-organism like mycorrhiza or in the case of N-fixing trees rhizobium are applied to the sowing site and can provide better growth and survival of the future trees (Peter 2001; Jasper 1990; Somasegaran & Hoben 1994).

Many tropical species have recalcitrant seeds, meaning that the seeds deteriorate rapidly after collection and can only be stored for a short period. So we need to reduce time between collection and seeding. It will then be recommended to collect the seed from a site and immediately sow at the planned site. This is more efficient compared to taking the seed to a central processing centre and a nursery and then seeding later. This solution will improve germination and possibly a higher overall percentage of established plants.

In areas with seasonal rains, time for direct seeding will thus naturally be at the beginning of the wet season (July in many areas), just after collection of the seeds, where the rains will provide a good start for the seedlings. In order to compete with the competing weeds, it would be sensible to choose fast growing species for reforestation for example Acacia spp., Leucaena, *Cajanus cajan* or Sesbania spp. In order to obtain more valuable forest products, direct seeding of native primary forest species could be carried out at a later stage when the weeds have been outcompeted and when the soil is improved with nutrients.

Enrichment planting of wildlings of desirable species

Wildlings are naturally germinated seedlings under or near mother trees, typically collected from forest areas. Where large-scale planting of native species - and particularly use of endemic germplasm – is required, it becomes necessary to develop a carefully planned wildling collection and planting strategy. Ethiopia has many valuable endemic plants which are at the risk. The future generation do need to benefit from these genetic resources. Some of them have difficulty to get their seeds as they have sporadic seeding pattern.

Silvicultural Management of ANR and Liberation Cutting

The approach of assisted natural regeneration (ANR) aims to strike a balance between high-cost restoration planting to restore biodiversity to small areas and the establishment of commercial plantations over large areas to restore productivity. ANR is a simple, inexpensive, and effective technique for converting areas of degraded vegetation to more productive forests. ANR accelerates succession by removing or reducing barriers to natural forest regeneration: weed competition is reduced, disturbances are prevented, unsuitable microclimate is ameliorated by the accelerated growth of naturally established pioneers, and seed dispersal into the site by birds and animals is enhanced by the restoration of forest habitat. ANR offers significant cost advantages because the costs associated with propagating, raising, and planting seedlings are eliminated or reduced.

The ANR approach has been used to restore forests in many countries. Countries like the Philippines and Thailand have successfully practiced ANR as a method of forest restoration and management. The ANR approach, under different names, has been implemented in combination with other forest restoration methods in China, Nepal, Ethiopia, Nigeria, and Sri Lanka.

ANR's applicability covers a broad range of forest types and geographical areas. The techniques can be adapted to meet various objectives such as income generation from non-timber forest products (NTFPs), production of firewood and timber, and biodiversity conservation. Despite its practical benefits, ANR's potential as a low-cost forest restoration method is not well recognized and the method is underutilized.

ANR is most suitable for restoring areas where some level of natural succession is in progress. As a first condition, sufficient tree regeneration must be present so that their growth can be accelerated. Seedlings of pioneer tree species are often found among and below the weedy vegetation even on a seemingly weed-dominated land. Supplemental planting can be carried out if the density of natural regeneration is not sufficient. To ensure further successional development, remnant forest should be in proximity so that there would be sufficient input of seeds.

Most importantly, it must be possible to prevent further disturbances such as fire, grazing, and illegal logging because the success of ANR ultimately depends on the continued protection of the site.

A variety of technical methods are used in applying ANR, and the following basic steps can be applied according to site conditions, restoration objectives, and resource availability.

1. **Marking of Woody Regeneration.** Once the target area is identified and its boundaries are demarcated, the site is surveyed to assess its successional status and to locate any natural woody regeneration growing above and below the weedy vegetation. The located seedlings should be clearly marked with stakes to facilitate the application of subsequent treatments and to protect them. The marked seedlings should be tagged, identified, and measured for monitoring of growth and survival rates.
2. **Liberation and Tending of Woody Regeneration.** The next step is to accelerate the growth of the marked seedlings by reducing competition from the weedy species for water, nutrients, and light. The initial treatment should be implemented at the onset of the rainy season so that the liberated seedlings will have the full growing season of accelerated growth. All competing vegetations such as grasses and bushes within at least 0.5 m radius around the stem of the marked seedlings are removed. This can be done by slashing then hand cultivating or by manually digging out the competition. Fertilizers or manure may be applied to the seedlings to further enhance their growth.
3. **Suppressing of Weedy Vegetation.** Once the desired number of wildlings has been marked and ring-weeded, the suppression of other weedy vegetation throughout the site is the next critical step. In addition to reducing weed competition, it reduces fire hazard and makes movement at the site easier. This is done by clearing with wooden boards machet.
4. **Protection From Disturbance.** Protecting against fire and other forms of disturbance is the most important ANR activity. All work done in the area is wasted if fire destroys the liberated seedlings or if they are damaged by animals or human activities.
5. **Maintenance and Enrichment Planting.** The maintenance of ring weeding, and liberation of any additional seedlings that establish or that are newly found, should be conducted every 1–1.5 months during the rainy season and every 2–3 months during the dry season. Enrichment planting can also be carried out to accelerate canopy closure, add useful tree species, and increase floristic diversity. Even after the resto-

ration of canopy cover, large-seeded primary forest trees and rare species are unlikely to colonize naturally. If restoring floristic diversity of the original forest is one of the restoration objectives, species or functional groups of trees lacking in natural regeneration will need to be planted either at the initial treatment stage or after canopy closure depending on the ecological requirements of the species.

4.2.3. Small-scale Plantations-Establishment and Management Techniques

Selecting species matching with the purpose and the site

Species selection should be conducted carefully in order to ensure successful establishment of small-scale plantations. The site to be planted and its productivity determines the species to be planted in a site. Species to be planted in small-scale plantation should be suitable to the objective the plantation establishment. Currently, most of the small scale plantations are carried out for the purpose producing small production poles. Therefore, species selection should take species attributes such as fast growth, street pole and less tapering. In some places, farmers combine tree planting with crop production at the early stage. In such areas, besides the recommended tree attributes, species selection should avoid species that release allelophatic chemicals and compete with crops. Species selection should also take into account the edaphic and climatic conditions of the planting sites. More drought tolerant species and provenances should be planted in moisture deficit areas. Likewise, species that can grow under marginal soil condition should be planted in shallow, infertile and degraded sites. Although species require specific site conditions, species that are commonly considered suitable to smallholder plantation include *Eucalyptus globulus, Eucalyptus camaldulensis, Gravilea robusta, Acacia decurrens*.

Site preparation and planting

Site preparation includes all planned activities carried out in the plantation site with the purpose of creating favorable condition for tree planting. Site preparation is needed before planting trees to control competing vegetation and to loosen soils, thereby improving soil structure and increasing macropore space. This facilitates water movement and/or water retention. Site preparation also helps in creating good planting holes.

Properly prepared sites provide better growing conditions to the planted seedlings and improve survival by improving the newly planted seedling's access to nutrient, water, space and sunlight which are essential for survival and growth. Site preparation includes clearing of grasses, weeds, and brush growing on the planting site that competes. Site clearing does not mean removing the entire vegetation of a planting site. Removal of unwanted vegetation should be conducted along the tree planting strip or around a small circle surrounding the planted tree. In both cases a weed free zone of 60 cm should be maintained. If the planting site is sloppy and exposed to soil erosion, vegetation removal along the planting strip is recommended. Vegetation can be effectively controlled by either mechanical methods or by the use of herbicides. In many situations the best results are obtained by using a combination of both. Therefore, unwanted vegetation should be removed at least two-four weeks before preparation of planting holes. This will help in monitoring some re-colonizing species. it is also important to establish drainage canals If the tree planting site accumulates water for long period of time.

Besides, site clearing there are other important practices that should be conducted during site preparation. Fencing is one of the practices that significantly affect the success of small-scale plantations. Given the free grazing of livestock in most parts of Ethiopia, protection through fencing is crucial. Fences can be constructed from locally available materials. But live fence, whenever possible, is recommended. Live fence species such as euphorbia, *Dovyalis abyssinica* or other species known in the locality can be used. If the site is prone to fire, firebreaks should be established around the stand. All combustible materials should be removed from the fire line. The fire break should be regularly repaired.

Preparation of planting holes follows vegetation removal. Plantation holes shall have 20-40 cm diameter and a depth of 20-30 cm. The planting hole size should be decided based on the site condition. Planting holes in law rainfall areas with shallow soils should be bigger. In moisture deficit areas, planting holes should be prepared with soil and water conservation structures such half-moon and deep trenches. Planting holes should be spaced based on the objective and the planting stock decided for the small-scale plantation. Assuming most of the small-scale plantations established in Ethiopia are for small production that can be harvested within four to five years, a planting stock not exceeding 2500 seedlings/ha is recommended. For a planting stock of 2500 seedlings/ha, the spacing between holes should be 2mX2m. If small-scale plantations are planned for the production of timber and big construction poles, wider spacing of 2mX3m to 3mX3m with a planting stock of 1000-1500 seedlings/ha is recommended.

The success of tree planting is significantly dependent on the quality of the planted seedlings. Seedlings should be carefully graded and selected in the nursery. The healthiest and vigorous ones should be planted. Too small, bended, diseased seedlings should be avoided. Seedlings raised in pots have to be used. The proportion between the shoot and the root should be maintained. Recent observations demonstrated that seedlings with long nursery life better endure the stress in planting sites and show better survival. Farmers shall try whether such seedlings are suitable to their circumstances. In this exercise, it is advised to check the significance of additional costs incurred. Planting should be conducted when the soil is adequately wet to a depth of 20-30 cm. Cloudy days are preferable for planting.

Establishing small-scale plantations in suitable niches

Small scale plantations can be established in different parts of the rural landscape. Plantations can be established in block or strips. Blocks or strips of small-scale plantations can be established within resident compounds of individuals, around farmlands, within communal grazing lands, open degraded communal lands, degraded community forestlands etc. Organized community members or individuals can establish small-scale plantations on any size of available land but the higher the land size the more the economic feasibility of the investment. Whenever it is possible, attempts should target to secure lands closer to roads and nearby markets.

Post planting silvicultural management of small scale plantation

Planting should be followed with series of important management practices. Cultivating and weeding to enhance aeration to the roots of the seedlings and to remove weeds is a practice that must be done right after the end of the rainy season. Weeding should make sure that the weeds are properly uprooted. In moisture deficit areas, planted seedlings need to be regularly watered. If natural water sources are not available, ponds should be established. Seedlings planted in moisture deficit areas should be watered at least for 2-3 seasons. Similarly, seedlings planted in degraded areas should be supplied with manure/compost to improve nutrient availability. Improving availability of macro nutrients such as Nitrogen, Phosphorous and Potassium through manure and compost improves growth and productivity of seedlings planted in small-scale plantations.

Post planting management includes pre-commercial thinning which can be conducted 3-4 years after small-scale plantations established for small pole production. Pre-commercial thinning should be planned after careful assessment of the plantation. Individual trees which are deformed, diseased and dying that are not preferred in the targeted market should be removed. The trees, however, removed during the pre-commercial thinning can be supplied to the local market and serve as a source of intermediate income. Moreover, removal through pre-commercial thinning offers more space and resource for enhanced growth of the remaining trees of the stand.

Harvesting is the other management activity in small-scale plantations. For forest plantations that are established for purposes of wood production, trees and shrubs are harvested once they attain the "optimum size" that suits the end product it is intended for. In small-scale plantations fast growing species established for pole production the common rotation age ranges between 5 and 7 years. The rotation age normally depends on the site productivity. In more productive sites harvesting can be conducted at the 5th year of the plantation. Harvesting time should also consider the market condition to optimize the return from high market demand. Harvesting should also be conducted in a month of the year that do not affect the harvesting activities and obstruct the road access. The dry season beginning from October is more suitable to most of the areas. Decision of harvesting time should take the price and availability of labor into account. In most cases, harvesting is made through clear felling. In areas that have sloppy topography, removal of trees with clear felling may expose the site for soil erosion and selective harvesting must be employed. Processing of the harvested trees needs to be decided based on agreement made with the buyer. Owners of small-plantations should make a comparative assessment of returns from sale at stumpage against transporting processed poles to the nearby markets.

5. OTHER RELATED ISSUES

5.1. Preventing free grazing, wildfire and pests

If freegrazing is a challenge, long-term community involvement and support is critical in preventing the reoccurrence of disturbance events that will set back succession. Establishing firebreaks around blocks of ANR-treated sites is a must, if the area is prone to fire. The size of each block depends on the terrain and the amount of volatile material. Fires in flatter terrain tend to spread less quickly than on slopes, so blocks can be larger. Logically, where there is more flammable material, blocks should be smaller. A general guideline of four blocks per hectare has been suggested for grassland in the Philippines (Friday et al. 1999). Although the wider the better, experience has shown that at least 6 m is needed for firebreaks to be effective. Moreover, livestock should be supported through services related to feed supply, marketing systems, veterinary to improve productivity. Training on general husbandry practices should also be given to the livestock owners. Zero grazing - system that prevents livestock from grazing freely in open on rehabilitated land (livestock is confined in a stall and fed with cut and carried fodder-forage plant) is the preferred option. However, controlled grazing- system can be recommended depending on site and stand conditions. The later is done by regulating the amount of time and the amount of grazing that should take place within a particular area.

5.2. Value addition and marketing of products

Added value products from small-holder plantations boost the return and attract further investment. The current value chains of small pole marketing involve several intermediaries (or middle men), add little value to the products but add-up to market inefficiency. Small-holder planters should integrate themselves to create less fragmented value chains. Existing legal provisions support the establishment of unions and cooperatives. Organizing through cooperatives offers the opportunity to regulate the marketing chain, introduce technologies and diversify products. Product diversification (Bark for tannin, essential oils, timber, charcoal making, etc.) would help to maximize income from forest products of small-holder planters. Cooperatives facilitate better access to domestic and international markets. It also helps to improve the bargaining power. Cooperatives facilitate access to finance such as getting loan from a revolving fund, which helps to have capital that can be utilized to expand the market range and outreach wider markets. By organizing themselves under cooperatives small holder planters can process the poles in such a way that final consumers in different markets desire and can improve their gain. Small-holder tree planters that form cooperatives can request technical, financial and policy support from the government and other non-state actors. The government puts in place different capacity building packages that encourage small-scale investments and promote value addition and marketing.

5.3. Benefit sharing schemes

In many instances, stakeholders complain that the benefits obtained from rehabilitating a site remain minimal. The amount and speed of socioeconomic benefit obtained is a challenge that needs urgent solution. Exclosures are in most cases communal. Dwellers contribute in the establishment and protection but their rights are not well defined. The ownership types of exclosures are not well defined. Scaling-up of exclosures should take into account the need for defined ownership. The best model should be the one that fitsto the existing situation of an area where exclosure is scaled-up and meets community expectations. Creating a clear ownership or if communal, clear benefit sharing mechanism from the outset should be considered for the sustainability of exclosures.

Unclear benefit sharing mechanisms of the products and services obtained from rehabilitation of degraded lands are sources of conflict. Lack of a clear benefit sharing mechanism limits adoption and scaling up of the practice. Fair benefit sharing mechanism based on contribution should be in place. Sharing the benefits of exclosures among all beneficiaries on equitable bases increases the sense of ownership and participation of the community in management. Performance based benefit sharing triggers competition which enhances the productivity of the exclosure. Though the right choices could contextually vary, performance based benefit sharing should be favored as much as possible (CIFOR 2015). To achieve this, diversifying products and income from rehabilitation efforts are vital in ordertto provide attractive economic return from the practice. Income diversification schemes can be ensured through proactive and flexible management.

MONITORING AND EVALUATION

A detailed framework for monitoring and evaluation of rehabilitation efforts should be developed during the planning phase. Monitoring and evaluation will basically be based on objectively verified variables and indicators showing progress and impacts. Indicators showing changes in income and livelihood and environmental wellbeing should be considered. A baseline assessment should be conducted prior to the of interventions to ease the monitoring and evaluation. An adequate evaluation and assessment methodology must be established prior to extensive restoration treatments and project implementation. Collection of such baseline data will provide a tool for measuring success, observe management effectiveness, and evaluate long-term trends. Methodologies for measuring restoration effectiveness should be developed, installed, and monitored by independent team of experts.

An independent team of experts from relevant fields should envolve in conducting evaluation of completed interventions. There should be defined procedures and methodologies established before conducting monitoring and evaluation. However, this too has to include local stakeholders including communities. Feedbacks should be communicated to the reuired implementing partners and communities.

The ultimate goal of restoration monitoring is to provide the information necessary to answer specific management objectives. An adaptive management approach like that envisioned for the Restoration management planning is required. Monitoring should base on a robust monitoring program, an efficient data-storage and retrieval system, and synthesis of the monitoring information to provide the scientific knowledge needed for informed management decisions.

The monitoring plan should be designed with the aim of measuring progress towards meeting the restoration targets while providing information for specific management options and decisions in the future.

Table 1. Selected species monographs with some details of species characterization and habitat requirements

Species	Characteristics	Habitat Requirements
Acacia abyssinica		Dega
Acacia melanoxylon		Dega
Acacia albida	Genuinely multipurpose. Pods for fodder. Needs water-table.	Weyna Dega
Buddleja polystachya		
Acacia nilotica	Widespread in India and Africa. Likes deep soils and water-table. Good fuel/fodder. Fast grower.	Kolla
Acacia saligna	Introduced species from Australia. For dune fixaaation/fodder/windbreaks. Hardy. Fast grow-ing.	Weyena Dega and Kolla
Acacia senegal	" Gum arabic" tree producing commercial gum. Good also for fuelwood/fodder. Direct seeding	Kolla
Acacia Decurrens		Dega and Weyna Dega
Cordia africana		
Acacia seyal	Likes low lying areas with heavy soils which flood. Good forage/fuelwood. Quite fast early growth.	Weyna Dega
Acacia tortilis	"Umbrella thorn". Good fuelwood and charcoal. Branches for fencing. pods good fodder. Fast once established	Weyna Dega
Croton macrostachyus		Weyna Dega
Albizia gummifera		Weyna Dega
Albizia lebek	From India. Small shade/amenity tree in Sahel. Needs high water-table. Foliage for mulch. Rapid growth	Kolla
Arundinaria alpina		Dega
Carissa endulis		Weyna Dega and Kolla

Azadirachata indica	Neem treee: from India/Burma. Grown mainly for shade but is also good fodder/fuel. Fast growing.	Weyna Dega and Kolla
Balanites aegyptiaca	"Desert date" widespread and-ecologically: "flexi-ble". Fodder/edible fruit. Direct seeding possible. Slow growing	Kolla
Casuarina equisetifolia		Weyna Dega and Kolla
Cassia siamea	Grown for shade, amenity, fuelwood and poles. Better with higher rainfall. Direct seeding possible. Quick growing	
Dodonaea angustifolia		Kolla
Grevillea robusta		Dega and Weyna Dega
Casuarina equisetifolia	ood on deep sands (also at coasts) so used for dune stabilization. Also fuelwood. Fast growing.	All
Cajanus cajan		All
Chamaecytisus palmensis		Dega and Weyna Dega
Cordia africana		Weyna Dega
Sesbania sesban		
Vernonia amygdalina		
Acacia nilotica		
Eucalyptus camaldulensis	From Australia. Best eucalyptus for dry areas. Cop-pioes well. Windbreak/fuelwood. Very quick growing	Weyna Dega and Kolla
Prosoppis julliflora	Very drought resistant and establishes naturally. May invade potential areas. Coppices well. Good for fuel supply. Pods are used for fodder. Quick growth.	Kolla

Ziziphus spinachristi	"Jujube". produces edible fruit. Can be grafted. Small tree. Branches for fencing. Slow growth.	
Eucalyptus globulus		Dega and Weyna dega
Maesa lanceolata		Dega
Hygenia abyssinica		
Moringa stenopetala		Weyna Dega and Kolla
Olea europaea		
Parkinsonia aculeata		
Rhamnus prinoides		
Schinus molle		
Sesbania sesban		
Syzygium guineense		
Tamarindus indica		
Terminalia brownii		

REFERENCES

Ganz, D. J., and P. B. Durst. 2003. Assisted natural regeneration: an overview. Pages 1–4 in P. C. Dugan, P. B. Durst, D. J. Ganz and P. J. McKenzie, editors. Advancing assisted natural regeneration (ANR) in Asia and the Pacific. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, Bangkok, Thailand.

Peter Ochsner. 2001. Direct Seeding in the Tropics. Danida Forest Seed Centre, Denmark

Xinhua, C. & Jingchun, Z. 1988. Sowing from the air: China's experience. Tigerpaper vol. XV: No.1. FAO forest news.

Mann, W.F. and Derr, H.J. (1964). Guides for direct-seeding slash pine. U.S. forest Service Research Paper SO-12 U.S. Dept. of Agriculture.

Jasper, D. (1990). The role of vesicular-arbuscular (VA) mycorrhizal fungi in regeneration. 'Sowing the seeds' Direct seeding and natural regeneration conference. Greening Australia Ltd.

Somasegaran, P. & Hoben, H.J. (1994). Handbook for rhizobia. Springer-Verlag. New York.

Muys B., Gebrehiwot K., Bruneel S. (2006). The ecology and silviculture of dryland forest rehabilitation in Ethiopia. Journal of the Drylands 1(1): 1–2.

ITTO (2002). ITTO guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests. ITTO Policy Development Series No.13. Yokohama, Japan, ITTO, CIFOR, FAO, IUCN, WWF International. 84 p.

CIFOR, Center for International Forestry Research, Ethiopia. Guidelines for Scaling Up Best Practices in Sustainable Forest Management.

CRGE (2011). Ethiopia's Climate-Resilient Green Economy: Green economy strategy. Available at: http://www.undp.org/content/dam/ethiopia/docs/Ethiopia%20CRGE.pdf

FDRE (2015). Ethiopia - Land Degradation Neutrality National Report to UNCCD. Federal Democratic Republic of Ethiopia. Available here: http://www.unccd.int/en/programmes/RioConventions/RioPlus20/Documents/LDN%20Project%20Country%20Reports/ethiopia-ldn-country-report-final.pdf

MEFCC (2016). The Contribution of Forests to National Income in Ethiopia and Linkages with REDD+. Authors: Smith R., McDougal, K. Metuzals, J., van Soesbergen, A. Unpublished UN-REDD Report.

Woody Biomass Inventory and Strategic Planning Project (WBISPP). 2004. Forest Resources of Ethiopia. Addis Ababa, Ethiopia.

Yemiru, T. 2011. "Participatory Forest Management for Sustainable Livelihoods in the Bale Mountains, Southern Ethiopia." Unpublished PhD thesis, Swedish University of Agricultural Sciences , Uppsala.

Friday, K., E. Drilling, and D. P. Garrity. 1999. Imperata grassland rehabilitation using agroforestry and assisted natural regeneration. International Center for Research on Agroforestry, Southeast Asia Regional Research Programme, Bogor, Indonesia.

Kebrome Tekele and Tesfaye Bekele. 2000.The Role of Soil Seed Banks in the Rehabilitation of Degraded Hillslopes in Southern Wello, Ethiopia' BlOTROPlCA 32: 23-32.

Tefera Mengistu, Demel Teketay, Håkan Hultén, and Yonas Yemshaw. 2005. The role of enclosures in the recovery of woody vegetation in degraded dryland hillsides of central and northern Ethiopia. Journal of Arid Environments 60:259–281.

Alemayehu Wassie, Frank J. Sterck, Demel Teketay, and Frans Bongers. 2009. Tree Regeneration in Church Forests of Ethiopia: Effects of Microsites and Management. BIOTROPICA 41: 110–119.

Eshetu Yirdaw. 2002. Restoration of the native woody-species diversity, using plantation species as foster trees, in the degraded highlands of Ethiopia. PhD Dissertation, Viikki Tropical Resources Institute, University of Helsinki, Finland.

Emiru et al. 2002. Actual and Potential Contributions of Enclosures to Enhance Biodiversity in Drylands of Eastern Tigray, with Particular Emphasis on Woody Plants. M.Sc. thesis, Swedish University of Agricultural Sciences, Sweden.

Wolde Mekuria, 2013. Changes in Regulating Ecosystem Services following Establishing Exclosures on Communal Grazing Lands in Ethiopia: A Synthesis. Journal of Ecosystems

Forest Conservation and Utilization Proclamation (2007)

Guideline for Participatory Forest Management in Ethiopia (2012)

Leonard Berry, 2003

FAO, 201

EFAP (1994),

Paulos, 2001

IFPRI, 2005

Fitsum et al., 1999

Gashaw et al., 2014

Horne, 1993; Tekle, 1999; Badeg, 2001; Delahunt, 2006

Badeg, 2001; Foil et al., 2002; Mekuria et al., 2011

Tekle, 1999

Mekuria et al., 2007

Shivered and Holden, 1999

Yeraswork, 2000

Horne, 1988

Lemenih, 2004

Teketay et al. 2010

Mengistu et al., 2005; SCIP, 2014

Lemenih and Kassa, 2014

Knowles and Parrotta, 1995

Shono et al., 2007

Parrotta et al., 1997; Senbeta et al., 2002