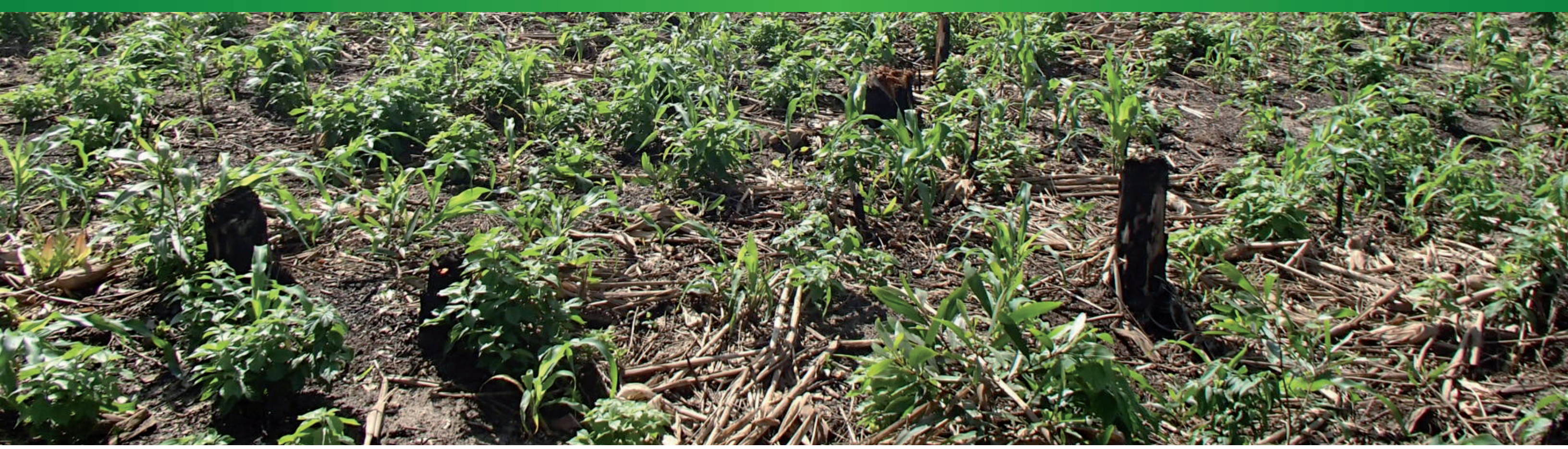
A PLATFORM FOR STAKEHOLDERS IN AFRICAN FORESTRY

RESTORATION PRACTICES IN DEGRADED LANDSCAPES OF EASTERN AFRICA



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Restoration practices in degraded landscapes of Eastern Africa

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Acronyms and abbreviations

AFF	African Forest Forum
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resource Management
CCP	Climate Change Programme
CDM	Carbon Development Mechanisms
DASS	Development Associates
DNRMP	District Natural Resources Management Project
EAC	East African Community
EACCP	East African Community Climate Change Policy
EIA	Environmental Impact Assessment
EUCAMP	East Usambara Conservation Area Management Project
FAO	Food and Agriculture Organization
GHGs	Green House Gases
HASHI	Hifadhi Ardhi Shinyanga
JFM	Joint Forest Management
LAMP	Land Management Programme
MDGs	Millennium Development Goals
MEMA	Matumizi Endelevu ya Misitu ya Asili
MNRP	Management of Natural Resources Programme
MNRT	Ministry of Natural Resources and Tourism
NAFRAC	Natural Forest Resource And Agroforestry Centre
NAMAs	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programme of Action

NGOs	Non-Governmental Organizations
PFM	Participatory Forest Management
REED	Reducing Emissions from Deforestation and Forest Degradation
SOI	Southern Oscillation Index
TATEDO	Tanzania Traditional Energy Development and Environment Organization
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
USD	United States Dollars

Executive summary

The highest deforestation and forest degradation rates in Africa occur in the dry forests and woodlands where the pressure for land is continuously increasing, poverty is rampant, livelihood options are few, and climate change effects are severe and expected to become even more severe. In addition, land and forest tenure and rights of access to forest and woodland resources are either not clearly defined or non-existent to many people. Restoration of degraded forest and tree resources as well as woodland areas, therefore, may contribute to both peoples' livelihoods and environmental quality. An assessment was conducted in some countries in Eastern Africa (EA) in order to document local experiences in restoring degraded forest and tree resources as well as woodland areas. The specific objectives of the study were to:

- assess ways and experiences farmers and other stakeholders have and are using to rehabilitate degraded lands, and forest and tree resources in woodlands and savannahs in EA;
- identify and describe the technologies and practices that have been very successful in rehabilitating degraded lands, and forest and tree resources in EA and the conditions for their success;
- evaluate the extent to which such successful technologies and practices and their prerequisite conditions can be up-scaled in woodlands and savannahs of EA.

Both published and grey literature was accessed from different sources to obtain data and/or information on land degradation and technologies used for rehabilitation/restoration in countries of EA. Literature review was supplemented by field visits in the western Tanzania region of Shinyanga where native forests have been subjected to intense human pressure in recent decades, resulting in severe deforestation and degradation. The western Tanzania area is characterized by a heavy grazing by the large number of animals and the use of forests as a source of energy. In addition, information on forest management from other regions of Tanzania was collected, especially, on Participatory Forest Management (PFM).

The study showed that natural regeneration through active involvement of local communities promoted under PFM and/or collaborative forest management, and supported by the new forestry legislation, is by far the most successful and promising option for restoration of the large areas of degraded lands in Eastern Africa. This is because local communities are allocated clear forest land rights, and their traditional knowledge and management practices (e.g. *Ngitili)* are taken into account.

Artificial regeneration through the woodlots or farm forests are prioritized in some countries for various reasons, including commercialization of tree planting in Uganda as out-growers, energy production in Rwanda and reforestation of bare hills in Ethiopia. There is also an opportunity to promote tree planting for carbon markets as is the case in Tanzania Community-Based REDD Mechanisms for Sustainable Forest Management REDD pilot projects.

Agroforestry is also recognized as an important avenue for rehabilitation of degraded areas, especially, to improve soil fertility and soil conservation. This is particularly of great importance in agro-ecosystems that support food and energy production while at the same time providing other ecosystem services.

Specifically under each objective, the following were concluded and/or recommended.

Experience for Rehabilitation

- Exclosures are prevalent in livestock farming areas of Tanzania and Ethiopia where they are used to encourage rehabilitation of degraded grazing areas.
- Traditional and improved agroforestry systems and technologies are used to rehabilitate land with the most common technologies being improved fallows, homegardens, boundary planting and contour hedgerows for soil conservation and improved soil fertility.
- Natural and assisted regeneration with coppicing and pollarding is the most common form of regeneration used in the region.

Successful Technologies and Practices

The successful technologies in EA include:

- exclosures for agropastrolists;
- agroforestry technologies: traditional homegardens, soil conservation and soil fertility enhancement;
- farm forestry in Kenya, Rwanda and Uganda; and
- CBNRM approaches.

Conditions for Up-Scaling Successful Technologies

- In future, there is need to relook at the forest and environmental policies, e.g. in Kenya and Ethiopia, to make them more enabling to forest restoration and land rehabilitation;

- Implementation of enabling polices that promote forest and land restoration through clear land tenure systems and the linkage of the energy policy to forest restoration because of the overreliance on the forest resource for energy in the region;
- The need to associate the forest and land restoration/rehabilitation implementation with forest enterprise development (e.g. Farm Forestry/Out-growers) and payment of environmental services.

CHAPTER 1 Background

One of the main problems affecting inhabitants in Sub-Saharan Africa (SSA), especially those residing in the rural areas, is land degradation, which is defined, in general terms, as a temporary or permanent decline in the productive capacity of the land (Stocking and Murnaghan, 2001). Chidumayo et al (2011) has defined the term woodland in the broadest sense as a variety of wooded vegetation formations in which the woody canopy covers more than 10% of the ground surface, under climatic conditions with a dry season of three months or more. This definition incorporates vegetation types commonly termed as woodland, shrubland, thicket, savanna, wooded grassland, as well as dry forest in its strict sense. While part of the Eastern Africa (EA) region is well endowed with forest resources and tree resources, including woodlands and savannahs, which contribute significantly to carbon sequestration, all forest areas and types are under major threat of deforestation. The major causes of deforestation and forest degradation include clearing for agriculture and settlement, cutting woody species for fuel and charcoal, overgrazing, wildfires and over-exploitation of wood resources for commercial purposes. Countries in EA use substantial quantities of fuelwood and charcoal as the principal energy source in many households. These demands have created characteristic rings of deforestation around cities and towns where forests and woodland are still available. These activities contribute to the increased emission of carbon dioxide into the atmosphere as the carbon sink is progressively reduced. This overdependence on forest is mostly due to lack of alternatives and efficient technologies for energy and agricultural production.

The resultant influence on climate change has been responsible for increase in rainfall in some parts, leading to floods and lack of rainfall in other parts of the region leading to droughts. Both of these have had impacts on ecosystem and biodiversity loss. Climate change will further exacerbate the situation, and species that will be more vulnerable are those with limited geographical range and drought/heat intolerance, low germination rates, low survival rate of seedlings and limited seed dispersal/migration capabilities.

Forest and tree resources, including woodlands and savannahs, have the greatest mitigation opportunities as net sinks of carbon dioxide through Reducing Emissions from Deforestation and Forest Degradation (REDD). Although some of the technological options can be exploited through market-based mechanisms, such as Clean Development Mechanism (CDM), more strategic support is required in areas where market based mechanisms may not be attractive. According to the East African Community Climate Change Policy (EACCCP, 2011), the main challenges related to forests that have been identified in order to address climate change include:

- maintenance or increase of biodiversity and regeneration potential due to ecosystem change;
- creation of alternative primary sources of energy and livelihood of the poor *vis-à-vis* forest products;
- reduction of bush and forest fires;
- restoration of the degraded wetlands;
- political will and commitment to conserve forests and wetlands;
- regeneration of forest cover due to human encroachment; and
- enabling all stakeholders, such as civil society, the private sector, community-based organizations, women and youth organizations, to fully participate in forest management practices.

The “Africa forests, people and climate change project” supports the emerging Climate Change Program (CCP) of the African Forest Forum (AFF) to further develop the forest-climate change nexus considered key for Africa’s future development (www.afforum.org, accessed on 01 February 2014). The purpose of the AFF-CCP is to better understand how forests and trees, and the people who depend on them, in the various African landscapes respond to climate change and variability. The emphasis of the project is on the development of the forest/climate change nexus in semi-arid areas (Sahel Belt), the woodlands of West, Eastern and Southern Africa and moist forests in Central and West Africa. As an overall strategy, the three working areas of policy and advocacy, capacity building and skills development as well as learning and knowledge management are closely interlinked.

The highest deforestation and forest degradation rates in Africa occur in countries with dry forests and woodlands where the pressure for land is continuously increasing, poverty is rampant, livelihood options are few and climate change effects are severe and are expected to become even more severe. Also, many of these countries have weak institutional structures for forest governance. In addition, land and forest tenure and rights of access to forest and woodland resources are either not clearly defined or non-existent to many people. Within such an environment, it becomes very difficult to implement policies that will not allow or seriously restrict people from, for example:

- cutting trees and clearing forests for cropland;
- collecting fodder for livestock or grazing livestock in the forests and woodlands;
- collecting firewood and making charcoal;

- harvesting timber and poles for domestic housing needs; and
- collecting non-timber forest products (NTFPs) that support their livelihoods.

These are the activities that are prevalent in African dry forests and woodlands, activities which hold potential to reduce poverty. Restoration of degraded forest and woodland areas, therefore, may contribute to both peoples’ livelihoods and environmental quality.

As stipulated in the Terms of References, the objectives of this study were to:

i) assess ways and experiences farmers and other stakeholders have and are using to rehabilitate degraded lands and forest and tree resources in woodlands and savannahs in EA, namely Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Tanzania and Uganda;

ii) identify and describe the technologies and practices that have been very successful in rehabilitating degraded lands and forest and tree resources in EA and the conditions for their success; and

iii) evaluate the extent to which such successful technologies and practices and their prerequisite conditions can be up-scaled in woodlands and savannahs of EA.

Both published and grey literature was accessed from different sources to obtain data and/or information on forest resource and land degradation and technologies used for rehabilitation/restoration in countries of EA. Due to resource constraints, literature review was supplemented by one field visit to the western Tanzania region of Shinyanga where native forests have been subjected to intense human pressure in recent decades, resulting in severe deforestation and degradation. The Western Tanzania area is characterized by a resource that has been subjected to heavy grazing by the large number of animals as well as the use of forests as a source of energy. In addition, information on forest management from other regions of Tanzania was also collected, especially on Participatory Forest Management.

CHAPTER 2 State of land degradation in woodlands and savannahs in Eastern Africa

OVERVIEW OF LAND DEGRADATION IN EASTERN AFRICA

Land is a primary asset for survival and development in EA. Land supports the livelihoods of most rural people where the populations are, generally, high. For instance, in Burundi, Eritrea, Ethiopia, Rwanda and Uganda, more than 80% of the population live in rural areas while the corresponding figure in Kenya and Somalia is > 60%. In contrast, only 16.3% of the population live in rural areas in Djibouti (FAO, 2005). Across EA, habitat change is largely driven by anthropogenic factors resulting from competing uses of the land, deficient regulatory and enforcement instruments, poor or non-existent land tenure systems and lack of appreciation by policy makers of the intricate link between forest/tree resources and the livelihoods of people. The main human-induced habitat changes in the dry regions of EA include low input agriculture and, especially, pastoralist practices. For example, 70% of Kenya is semi-arid or arid, characterized by low, unreliable and poorly distributed rainfall. These areas are used for pastoral farming. In Tanzania the areas outside of reserves are under heavy pressure of conversion to other land uses, such as agriculture, wildlife reserves/parks, grazing and settlement areas as well as industrial activities. Deforestation is caused, mainly, by unsustainable agricultural practices and commercial timber exploitation, cutting of trees for fuelwood and charcoal, livestock grazing and wildfires.

According to UNEP (2006), EA has limited cover of forest resources, including woodlands, amounting to approximately 13% of the total land mass with variations in the different countries (Table 1). Tanzania is the most forested (44% of the total land mass), followed by Kenya (30%) and Uganda (21%) while Djibouti has the least cover with about 6,000 ha (0.3%) (FAO, 2005). Burundi is experiencing the highest decline in its cover of forest resources (9%) during the period 1990-2000 followed by Rwanda (3.9%), while Tanzania had the least decline (0.2%) (FAO, 2005).

Table 1. Forest area and area change in countries of Eastern Africa during 1990-2000

Country	Total land area ('000 ha)	Total forest area ('000 ha)	Proportion of forest area (%)	Annual change ('000 ha)	Annual rate of change (%)
Burundi	2,568	94	3.7	- 15	-9
Djibouti	2,317	6	0.3	NA	NA
Eritrea	11,759	1,585	13.5	- 5	- 0.3
Ethiopia	11,430	4,593	4.2	- 40	- 0.8
Kenya	56,915	17,093	30	- 93	- 0.5
Rwanda	2,466	307	12.4	- 15	- 3.9
Somalia	62,734	7,515	12.0	- 77	- 1.0
Tanzania	88,359	38,811	43.9	- 91	- 0.2
Uganda	19,964	4,190	21	- 91	- 2.0

Source: FAO (2005); NA = Not available.

Uganda has the highest proportion of potentially arable land, whereas in Rwanda, all arable land is in use and land pressure is pushing cultivation into marginal areas (Table 2). In Eritrea, 88% of the land is under cultivation. The small countries of Rwanda and Burundi face enormous challenges of high population densities, with about 340 and 266 persons per km^{-2}, respectively. In East Africa, more than one-third of the land area is covered with permanent pasture since the dominant land use is livestock grazing while about 73% of the total area is characterized by desert and dryland conditions, of which significant proportions fall in Djibouti, Eritrea and Somalia (Figure 1).

Table 2. Proportion of arable land in different countries of Eastern Africa

Country	Total area ('000 km²)	Potential arable land		Actual arable land (in 1994)	
		Area ('000 ha)	Proportion from the total area (%)	Area ('000)	Proportion from the potential arable land (%)
Burundi	26	1,414	54.4	1,180	83.5
Djibouti	23	0	0	0	0.0
Ethiopia	1,101	42,945	39	11,012	25.6
Eritrea	94	590	6.3	519	88.0
Kenya	569	15,845	27.8	4,520	28.5
Rwanda	25	746	29.8	1,170	156.8
Somalia	627	2,381	3.8	1,020	42.8
Tanzania*					
Uganda	200	14,169	70.8	6,800	48.0

Source: UNEP (2007); * Data provided for Tanzania: Total area of 94.5 million ha and arable area of 4.0 million ha (see p106 http://www.unep.org/dewa/africa/docs/en/aeo-2/chapters/aeo-2_ch03_LAND.pdf).

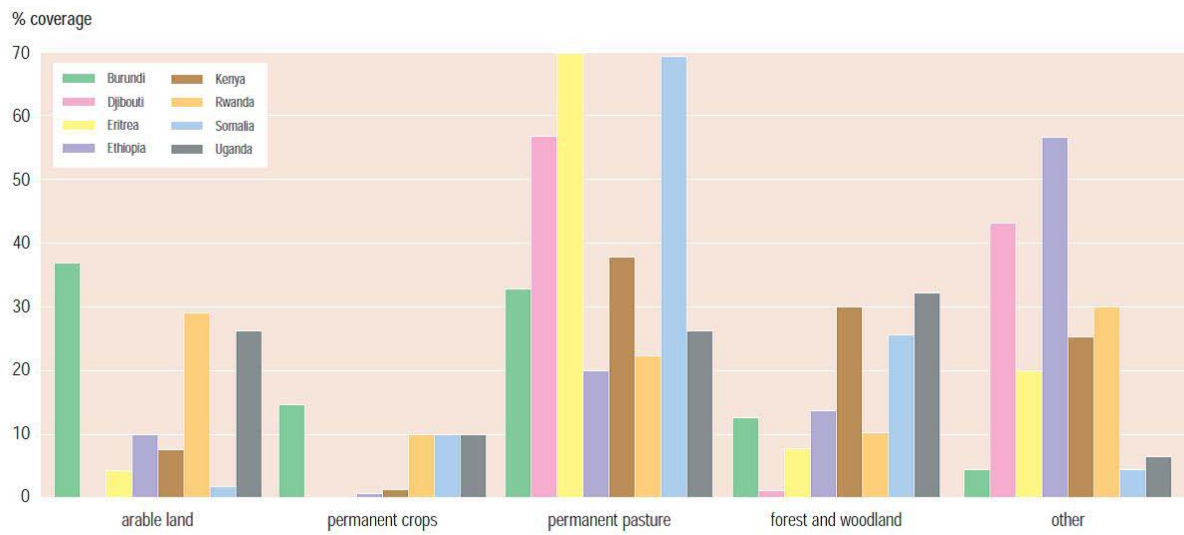

Figure 1. Land use and land cover in countries of Eastern Africa (1994) (source: UNEP, 2007)

Land degradation is wide spread in EA (Table 3). According to FAOSTAT 2005 (UNEP, 2007), Burundi and Rwanda face a serious threat of land degradation where about 76 and 71% of their respective country's total area of land mass encounters very severe degradation problems. They are followed by Eritrea, Uganda, Kenya and Ethiopia where areas with severe to very severe degradation constitute about 63, 53, 30 and 26%, respectively, of total area of land mass. In Djibouti, wind erosion is the principal form of erosion, but is, mainly, viewed as "natural" due to the absence of agricultural land.

Table 3. Land degradation in Eastern Africa

Country	Total area ('000 km²)	Severe degradation		Very severe degradation	
		Area (%)	Area ('000 km²)	Area (%)	Area ('000 km²)
Burundi	26	0	0	0	0
Djibouti	23	0	0	0	0
Ethiopia	1,101	8	88.08	20	17.62
Eritrea	94	55	51.7	8	4.14
Kenya	569	19	108.11	11	11.89
Rwanda	25	0	0		
Somalia	627	0	0	15	0
Tanzania	NA	NA	NA	NA	NA
Uganda	200	41	82	12	9.84

Source: UNEP (2007); NA = data not available.

The pressures and driving forces leading to land degradation are similar across the countries of the sub-region, including over-cultivation, overgrazing and deforestation as highlighted above. The process of soil degradation is further affected by factors related to physical land attributes, such as topography, soil and rainfall conditions. Topography is an important consideration since many countries are mountainous. In order of magnitude, Rwanda, Burundi and Ethiopia encounter the highest potential erosion risk due to steep topography. The areas with the most severe land degradation are also those with the highest population density, such as in the central and northern highlands of Eritrea, Rwanda and Burundi.

DESCRIPTION AND IMPORTANCE OF FOREST AND TREE RESOURCES

Timberlake et al. (2010) have reported that most extensive dry woodlands and savannahs in EA are in the semi-arid zone, covering 1.6 million km^2 and comprise deciduous microphyllous bush land and thicket dominated by spiny species of *Acacia* and *Commiphora*. Other common woody plants are said to include species of *Grewia*, *Balanites* and various members of the Capparidaceae family, such as *Boscia* and *Cadaba*. The baobab tree (*Adansonia digitata* L.) is also characteristic at lower altitudes towards the coast and the environs of the Great Rift Valley. Parts of Tanzania are also covered by the Miombo woodlands. Abdallah and Monela (2007) showed that the Miombo woodlands make up about 90% of all forested land in Tanzania, equivalent to 44.6 million ha, out of which 54% is under general lands, which are under open access regimes and the central government forest reserves. The main concentrations of this formation in the country are found in the western zone (Tabora, Rukwa and Kigoma regions) and the southern zone (Iringa, Lindi, Mtwara and Ruvuma regions). The major plant species belong to the genera *Brachystegia* and *Jubernardia*. Other species commonly found in this group are *Pterocarpus angolensis* DC. (mninga), *Albizia* spp. and *Afzelia quanzensis* Welw. Most of these species are distributed on non-gazetted land (communal land) characterized by poor management and rapid deforestation and degradation through socio-economic activities.

Forest and tree resources are the main source of fuel for the majority of the households and, thus, directly linked to the main threats of deforestation. Annually, about 173 million m^3 of wood fuel and about 5.2 million m^3 of industrial round wood is produced, most of which is consumed within the sub-region (FAO, 2005). Throughout the sub-region, the rate of off-take from the forests is more than their natural regeneration capacity. Moreover, there is very little investment in forestation and reforestation initiatives.

CLIMATE CHANGE AND FOREST/TREE RESOURCES

Woodlands in Africa contain a high diversity of plant species with a high degree of endemism, and are, therefore, important for biodiversity conservation. In respect of climate change, emerging evidence also suggests that climate warming might reduce overall plant production in woodlands of EA (Chidumayo et al., 2011). Currently, evidence suggests that the climate in EA is warming at a faster rate than has been predicted from global models. For example, temperature rises of 0.25 - 0.5 °C per decade have been recorded in Kenya, Tanzania and Uganda (Ogutu et al., 2007, Chapman et al., 2005 in Chidumayo et al., 2011). Chidumayo et al. (2011) reported that there has been a decline in Normalized Difference Vegetation Index (NDVI) in the Mara-Serengeti ecosystem in EA and this has been attributed to the rise in minimum temperature (Oguto et al., 2007 in Chidumayo et al., 2011). They have also reported significant correlation between tree ring widths and (i) monthly precipitation, (ii) monthly maximum air temperature and (iii) monthly Southern Oscillation Index (SOI) value in long-term observations of *Isoberlinia tomentosa* trees in Tanzania (Trouet et al., 2001 in Chidumayo et al., 2011).

CHAPTER 3 Restoration approaches and practices in degraded landscapes of Eastern Africa

RESTORATION OF DEGRADED LANDSCAPES AND WOODLANDS

One of the practices employed for the restoration of degraded lands as well as forest and tree resources, including woodlands and savannahs, is known as area exclosure (also referred to as area enclosure; hereafter referred to as exclosure). Exclosure refers to the practice of land management that involves the exclusion of livestock and humans from openly accessing an area that is characterized by severe degradation (Aerts et al., 2009; Teketay et al., 2010). The purposes of exclusion of animals and humans are to prevent further degradation of the ecosystems, advance re-vegetation/forest regeneration and restore the overall ecological conditions of the areas. In area exclosures, restoration/rehabilitation is primarily a natural process and human inputs are limited to offering protection against interferences. For this reason, some call it “zero management” strategy for rehabilitation. The zero management makes it also the cheapest method of rehabilitation of degraded areas. Nonetheless, in few cases, exclosures are supplemented with enrichment plantings of native and/or exotic species as well as soil and water conservation activities to speed up the restoration processes (Teketay et al., 2010).

Exclosures implemented on degraded, generally open access land, in many dryland areas of EA have been used as mechanisms for environmental rehabilitation with a clear biophysical impact on large parts of the formerly degraded lands (Tucker and Murphy, 1997). For example, it has been shown that exclosures in Ethiopia (Mengistu et al., 2005a and b; Birhane et al., 2004, 2006) resulted in diameter frequency distributions of two woody species having almost an inverted J - shape with representation of a high number of woody species at lower diameter classes suggesting the potential of exclosures to restore degraded lands through the rehabilitation of woody species (Mekuria, 2007). Similarly in Tanzania, forests have been reserved by rural communities for a range of objectives, including cultural, traditional, ceremonial and more utilitarian purposes such as the conservation of dry season grazing areas. One area of Tanzania that has been well documented is Shinyanga Region, through a case study presented in this report. Through this project, large areas of woodland have been recovered using traditional ‘Wasukuma’ reserved areas called *ngitili* (‘exclosure’).

In Handeni District and the North Pare Mountains of Tanzania, over 7,000 ha of forests have been protected by traditional and customary means. Most of these forests are between 125 and 200 ha, with about 25-30 different traditionally reserved forests per village in Handeni. These forests are maintained primarily for spiritual and cultural purposes, including as sites for traditional rites and ceremonies (MNRT 2008).

Similarly, significant forest patches are conserved and managed as sacred grooves in and around churches, monasteries, graveyards, mosque compounds and other sacred sites in several parts of Ethiopia. Particularly, the northern highlands are almost devoid of forests, like in other areas, as these have been converted into farms and grazing lands leaving few patchy remnants confined, mainly, around Churches (Wassie et al., 2005a and b; Aerts et al., 2006; Bongers et al., 2006; Wassie, 2007; Wassie and Teketay, 2006; Wassie et al., 2009a; Wassie et al., 2009and b; Teketay et al., 2010). For instance, Wassie et al. (2009b), in their study of 28 Orthodox Churches in Northern Ethiopia, found a total of 500.8 ha of remnant forests around them (average of 17.9 ha/church), and recorded 160 indigenous and eight exotic woody species (100 tree species, 51 shrubs and 17 lianas). The total number of species per Church ranged from 15 to 78. The species composition of these church forests are old growth type predominated by *Juniperus procera* Hochst. ex Endl., *Olea europaea* L. subsp. *cuspidata* (Wall. ex G. Don.) Cif. and *Celtis africana* Burm. f. According to Wassie (2007), there are 35,000 similar churches throughout Ethiopia that are likely to contribute to the conservation of considerable areas of remnant dry forests in Ethiopia. These forests are not only remnants of old-growth vegetation but also provide diverse forest products and services, and may act as sources of genetic materials for restoration of degraded dry Afromontane forests. Linked through appropriate vegetation corridors they may form a unique landscape matrix for large scale landscape restoration. Recent studies on management interventions (e.g. seed sowing, seedling planting, soil scarification, exclosing) in and around these forests (Wassie, 2007; Wassie et al., 2009b) show promising results in this respect.

The management practices for, especially, miombo woodlands in EA are designed to meet specific tangible products (Chidumayo et al., 1996; Dewees et al., 2011). Wood production, for example, in miombo woodland is also affected by the way miombo trees respond to harvesting. Responses depend on the phenological state, degree of resistance to fire, ability to resprout, seeding patterns, seed germination characteristics and seedling development (Chidumayo et al., 1996). Miombo woodlands usually respond to wood harvesting by coppice regeneration, but the rate of regeneration is affected by human activities. In Tanzania, the past management of miombo woodlands used early burning to protect regeneration of saplings from destructive late dry season fires. Other practices included singling of coppices and enrichment planting, especially, in upland rain forests.

In Western Kenya, two techniques of natural forest rehabilitation have been used in the dry areas, namely natural regeneration and aided regeneration. Natural regeneration involves protecting rehabilitation sites from external interference, through exclosures, to facilitate natural regeneration. The technique is employed in situations where there are some trees left in the landscape to act as seed sources during secondary succession. Aided regeneration, on the other hand, involves planting indigenous tree species that have been identified to dominate the degraded sites during early stages of secondary forest succession. The trees planted are intended to act as nurse trees that provide shade, enrich the soil and the microhabitat for naturally recruiting woody species. The technique is employed in situations where deforestation has led to loss of seed sources and in areas where harsh site conditions are unfavourable for natural regeneration.

RESTORATION OF FOREST AND TREE RESOURCES

Sustainably managed forest and tree resources, including woodlands and savannah, provide a wide range of goods and services to society at large and communities living adjacent these resources in particular. However, EA is facing crisis associated with these resources that negatively impacts upon people's livelihoods and severely limits governments' options to reduce poverty. The remaining forests are becoming increasingly degraded through legal and illegal activities, including encroachment, unsustainable harvesting of fuelwood and charcoal making, selective logging, uncontrolled *shamba* systems, uncontrolled fires, unsustainable agriculture, overgrazing, quarrying and soil harvesting.

In Tanzania, most of this loss is in non-gazetted land. In Uganda, the Government, NGOs, communities, individual households and the private sector have all been involved in forest restoration initiatives over the past decades with considerable success. However, there is a need for further initiatives in Forest Landscape Restoration because there is still a negative net loss in forest cover countrywide. This should also be true for most of the countries in East Africa, especially in countries like Burundi, Rwanda and Uganda (see Table 1). In Kenya, as one of the strategies to counter the decrease in forest cover, the government banned tree harvesting in state forests and encouraged farm forestry. The Agriculture Act (Cap. 318) on Farm Forestry Rules stipulates a 10% forest cover on farms while the Forestry Policy provides enabling environment for tree planting, utilization and marketing.

The choice of techniques for rehabilitating specific degraded areas depends first on the priorities and management objectives of stakeholders followed by the costs and benefits associated with available rehabilitation techniques as well as the economic, social, and environmental values of the land resources in their current and desired future states. Some of the rehabilitation techniques identified in the EA include natural regeneration, assisted natural regeneration, fire, enrichment planting, artificial tree planting and agroforestry. The common feature in dry areas inhabited by pastoralists is the use of exclosures to promote restoration of degraded lands.

Natural regeneration

Miombo woodland species regenerate, largely, through coppice re-growth and root suckers rather than through seeds. Chidumayo (1988) observed that stumps of almost all miombo woodland trees have the ability to produce sucker shoots. Although seeds of majority of miombo trees and shrubs germinate immediately after dispersal when there is enough moisture, tree density in re-growth miombo woodland decreases with time due to moisture and heat stress. The majority of seedlings of miombo trees experience a prolonged period of successive shoot dieback during their development phase in order to cater for these stresses. Shoot dieback is caused by water stress and/or fire during the dry season. Also, with the case of suckers and coppice, fire can either slow or accelerate growth. If a destructive fire occurs before dominant shoots attain a safe height to escape mortality, the process of sucker shoot domination reverts to the initial stage and stumps respond by producing an equal or larger number of replacement shoots (Chidumayo, 1988). However, resistance to these environmental factors varies with species.

Fire was found to be the major ecological factor, which leads to the development of miombo woodlands (Lawton, 1978). The impact of fire on miombo depends on time and frequency of burning and on the flammable biomass. Trapnell (1959) reported that repeated late and hot fires may destroy the woodland. While early burning maintained regeneration, complete protection leads to the development of a more closed, partly, evergreen forest. On the other hand, complete protection for a few years leads to an accumulation of fuel, which is more detrimental to tree biomass if fire occurs.

It, therefore, follows that for the woodland to thrive better, fire management regime should be practiced. It is generally agreed that one of the best ways of protecting and managing miombo woodlands is to carry out early burning, i.e., to burn patches of grass and undergrowth in the early dry season before the grass gets too dry in order to avoid more intense and damaging fires later in the season. However, research on fire management has not been conclusively conducted with most of the evidence being anecdotal.

In summary, with the exception of Kenya for natural regeneration, both natural and assisted natural regeneration have been reported to be used in forest restoration in Ethiopia, Tanzania, Uganda and Uganda (Table 4). On the other hand, forest management in the form of coppicing and pollarding is practiced in almost all the countries of the region. Fire has only been reported in Ethiopia as a management tool while other countries, like Tanzania, have acknowledged prevalence of fires, especially in the miombo as part of the ecological dynamics.

Table 4. Some natural regeneration techniques practiced in some countries of Eastern Africa

Country	Natural regeneration	Assisted natural regeneration	Coppicing	Pollarding	Fire
Burundi			√	√	
Djibouti			√	√	
Ethiopia	√	√	√	√	√
Eritrea			√	√	
Kenya		√	√	√	
Rwanda			√	√	
Somalia			√	√	
Tanzania	√	√	√	√	
Uganda	√	√	√	√	

Agroforestry

Rehabilitation of the land through agroforestry is the most common on human dominated landscapes where trees with multipurpose characteristics are used, including some nitrogen fixing species for soil fertility improvement as well as wood and fibre, and fruit trees. The tree species used for soil fertility enhancement have been popularised both in Eastern and Southern Africa as fertilizer trees (Mafongoya et al., 2006; Akinnifesi et al., 2010). Fertiliser tree systems involve soil fertility replenishment through on-farm management of nitrogen-fixing trees (Mafongoya et al., 2006). They represent a new paradigm because they use a completely different approach to land use management by smallholder farmers. Firstly, fertiliser tree systems capitalise on biological N-fixation by legumes to capture atmospheric N and make it available to crops. Secondly, they permit growing of trees in association with crops in space or time to benefit from complementarity in resource use (Gathumbi et al., 2002). Thirdly, they address most of the biophysical and socio-economic limitations identified with the earlier technologies based on using N-fixing tree legumes, such as green manures (Akinnifesi et al., 2008, 2010).

The most common agroforestry technologies promoted in EA include improved fallows in Western Kenya and rotational woodlots in dryland Western Tanzania (Table 5). Traditional systems include the *Faidherbia albida* (Del.) A. Chev.-based parkland systems. Studies in Tanzania by Kaoneka and Solberg (1994) demonstrated that the *Shambaa* people use their traditional agroforestry and intercropping systems to improve soil productivity and crops yields. This traditional agroforestry system consists of the multi-storey tree garden, which involves the mixing of trees and farm crops in a spatial arrangement.

Table 5. Some agroforestry systems and technologies in Eastern Africa

Country	Agroforestry system/technology						
	Improved fallows	Rotational woodlots	Contour hedgerows	Exclosure/Ngitiri	Boundary planting	Home-gardens	Farm-forestry
Burundi							
Djibouti							
Ethiopia				√		√	
Eritrea							
Kenya	√		√		√		√
Rwanda	√		√		√		√
Somalia							
Tanzania		√		√		√	
Uganda	√		√		√	√	√

The system includes a spatial mixture of an under-storey of coffee (and fruits), food crops, such as maize/beans and a variety of pulses, a middle storey of *Grevillea robusta* A. Cunn., a multipurpose species commonly used for timber, fuelwood and building poles production. Another traditional Agroforestry system is the *Ngitili* that has been widely reported and is based on the use of exclosure systems that allow the trees to either naturally regenerate or be assisted to regenerate while at the same also providing for animal fodder (reported as case study separately).

Plantations and woodlots

According to Chamshama (2011), public forest plantations dominate the region with a coverage of approximately 1,288,000 ha compared with 220,500 ha for private sector plantations (Table 6). He also points out that in the 1970s and 1980s, emphasis was put on the establishment of woodlots as individual or community forestry undertakings and for environmental rehabilitation purposes as a result of increasing concern over the rapid deforestation in many tropical countries. However, the performances of the woodlots are affected by many silvicultural, political and financial constraints. According to Chamshama (2011), several countries in the region have their forest plantations dominated by a few tree species.

For example, in Kenya, *Cupressus lusitanica* Miller comprises 54% of the plantation areas followed by pines at 24%. In Ethiopia, the main species in the plantations are eucalypts covering 56% and *C. lusitanica*, which covers 32% of the total area, followed by *J. procera* (2%), *Pinus patula* Schlechtendal & Chamisso (1.8%) and other species (8%). In Sudan, the dominant plantation species are acacias, viz. *Acacia senegal* (L.) Willd. (for gum Arabic production) and *A. nilotica* (L.) Willd. for timber and other utility wood. In Tanzania, pines are the dominant species in most of the government and private plantations with about 78% of the total area planted and the remaining 22% is shared among hardwoods and other softwood species. In Rwanda, *Eucalyptus* spp. (*E. camaldulensis* Dehnh., *E. dunnii* Maiden; *E. globulus* Labill. subsp. *globulus, E. globulus* Labill. subsp. *maidenii* (F. Muell.) Kirkpatr., *E. grandis* Maiden, *E. maculata* Hook., *E. microcorys* F. Muell.; *E. saligna* Smith and *E. tereticornis* Smith) cover over 55% of the area. In Uganda, *Pinus caribaea* Morelet and *E. grandis* are the main plantation species.

There is obviously a greater need to diversify the tree species used, especially, at on-farm level due to the different product needs by the farmers. Sudan has the largest area available for expansion of plantations (8.4 million ha). There is a wide range of partnerships between companies and communities with different arrangements between the growers and processors. Other than woodlots and plantations established under out-grower schemes, woodlots are also established by individual farmers and communities using their own, government or development partner resources for various products, e.g. wood fuel, building poles, sawn timber or environmental services.

The major problems identified in tree planting by the individuals include poor land tenure, limited extension services and financing mechanisms and low quality germplasm. Notwithstanding, the introduction of participatory forest management (PFM) seems to have encouraged natural and assisted regeneration, control of fires and respect for boundaries in the case of Ethiopia and Tanzania (Tsegaye, 2008 in Chamshama, 2011; MNTR, 2008). Avenues for promotion of tree planting in the region include national forest funds as is the case in Tanzania, private sector, development partners, international conventions and agreements and lately carbon financing activities.

Table 6. Area (ha) of forest plantations in countries of Eastern Africa

Country	Area (ha)			Afforestation species
	Public	Private	New Areas	
Burundi	80, 829	4,226	-	-
Ethiopia	190,400	-	2,100	*C. lusitanica, P. patula, G. robusta, Eucalyptus* spp.
Kenya	12,500	-	-	-
Rwanda	138,348	2,058	-	-
Tanzania	86,615	40,000	167,000	-
Uganda	14,140	48,090	154,100	Species of *Pinus, Cupresssus* and *Eucalyptus*
Sudan	654,340	126,075	8,410,000	*A. nilotica, A. senegal, C. lusitanica* and *Eucalyptus* spp.
Total	**1,164,340**	**126,075**	**8,733,200**	

Source: Adopted from Chamshama (2011).

Biodiversity

EA contains some of the world's oldest and richest protected areas, such as the Tsavo, Queen Elizabeth and Serengeti national parks. These protected areas were established in the hope that they would continue to exist in pristine state and effectively conserve the inherent biological diversity, especially the characteristic large mammal aggregations. However, rapid biodiversity loss in some of Kenya's protected areas has been reported to be closely linked with the explosion of tourism. The conflict between people and wildlife has also contributed to biodiversity loss. EA has a high human population and the spread of cultivation and settlement has meant that pastoralists and their livestock have been squeezed into increasingly smaller areas. There is increasing competition among people as well as between people and wildlife for grazing land and water resources (UNEP, 2007). Eritrea (19%), Tanzania (25%), Uganda (36%), Burundi (37%), Ethiopia (39%) and Rwanda (52%) are the countries which have seen high transformation of the land (Table 7).

Since the early 1990s, there has been a growing policy change focus on sustainable use and increased local participation. Nearly all countries are providing greater legitimacy for the involvement of people in natural resources management. In Kenya, for instance, a national land policy is being formulated through a consultative and participatory process. This should open up new opportunities for people wishing to invest in conservation and the sustainable use of biological diversity. In Tanzania, PFM of forests is fully operational (MNRT, 2008).

Table 7. Biodiversity richness and endemism in Eastern Africa

Country	Area (km^2)	Biodiversity opportunity (plant species)		Threat [proportion of land Transformed (%)]	Response [proportion of land Protected (%)]
		Endemic	Total		
Burundi	27,830	Unknown	2,500	37	5
Djibouti	23,200	6	826	1	1
Eritrea	117,600	Unknown	Unknown	19	4
Ethiopia	1,104,300	1,000	6,603	39	5
Kenya	580,370	265	6,506	13	6
Rwanda	26,340	26	2,288	52	8
Somalia	637,660	500	3,028	6	0
Tanzania	945,090	1,122	10,008	25	15
Uganda	241,040	Unknown	4,900	36	7

Source: Adopted from UNEP (2007).

REGIONAL APPROACHES

Policy and legal framework related to forest regeneration in the region

The practice of Joint Forest Management (JFM) and/or PFM in recent times has been accepted as the promising way for sustainable management of forest resources. It is well documented that PFM provides opportunities for local people to participate in forest restoration activities through conservation and management, thereby, contributing to improved status of the forests and the well-being of the local communities (Alden-Wily, 2002). Some countries in the region have changed their policies to address the involvement of communities in the management of the forests and woodlands. Most notable are Tanzania and Uganda. In Tanzania, the Forest Act (2002) used the Land Act (1999) and the Village Land Act (1999) as the basis for creating various forms of community involvement (Akida and Blomley, 2006). The Tanzania Forest Act 2002 (see Lovett, 2003) provides for local communities or individuals to jointly manage Central and Local Government Forest Reserves through JFM agreements and have their own Village Forest Reserves, which are managed by Forest Management Committees (Akida and Blomley, 2006). On the other hand, Uganda provides for different forms of land tenure, including customary ownership of land. The National Forest Plan distinguishes between forests owned individually or institutionally under freehold and leasehold tenure ("private forests"), and those owned communally under customary tenure ("customary forests").

In some countries of EA, a few policies have direct relation to forest restoration in terms of environmental and ecosystem conservation (Table 8). In Tanzania, the policy sectors that have very supportive statements on forest restoration include forest, environment, wildlife, fishery, energy and land. In Kenya, most of the policies, including the forest policy, are less supportive with the forest policy only stating that the government will promote tree planting and land rehabilitation by natural regeneration for wood production as well as protection of soil and water resources. The Environmental Management and Co-ordination Act of 1999, specifically, address forest regeneration by proposing for the re-afforestation and forestation of hilltops, hillsides and mountainous areas that will be identified by respective District Environment Committees. The Water Policy of 1999 proposes the identification and protection of water catchment areas, aiming at reducing pressure to allow for natural regeneration. In Ethiopia, the new legislation, Proclamation 542/2007, maintains the broad policy direction of its predecessor (Proclamation No. 94/1994) (Teketay et al., 2010). However, it has gone a step further in its people-centered approach by requiring communities to have a say in state forest management and by legalizing community access to forests for non-wood forest products. While it outlaws new settlements in state forests, the proclamation requires community welfare be given priority in issues of evictions. Principles of scientific management and multiple-use have been retained. An interesting departure, though, is the new provision for private ownership within existing natural forests and the strengthening of forest tenure. To its credit, the legislation emphasizes strong extension support, provision of germplasm, value adding and market support. Nevertheless, like all past forest legislation, the current proclamation leaves a huge institutional void and suggests the *status quo* of an uneasy marriage between the forest and agriculture sectors continue for forest management, extension and regulatory functions. In Rwanda and Uganda, the forest and environmental policies are also very enabling. For example, Rwanda has a strong legislative and policy framework, guided by the Organic Law Nr 4/2005, which lays out the modalities to protect, safeguard and promote environment in Rwanda.

Table 8. Analysis of policy and legal framework related to forest regeneration efforts in Eastern Africa

National Sector Policy	Tanzania	Kenya	Ethiopia	Uganda	Rwanda
Forest Policy	++	+	0	++	++
Environmental	++	+	+	++	++
Land	++	0	0	0	++
Water/Fisheries	++	0	0	0	0
Wildlife	++	0	0	0	0
Conservation	0	0	+	0	0
Energy	++	0	0	0	0

Source: Modified from IUCN-EARO and WWF-EARPO (2001; 2002a, b and c). Forest Landscape Restoration Reports: Key: + = supportive, ++ = very supportive and 0 = neutral or no information available).

CASE STUDY: LOCAL LEVEL PRACTICES IN TANZANIA

Forest landscape restoration is a process for re-establishing ecological integrity and enhancing human well-being in deforested or degraded landscapes. Natural regeneration, assisted natural regeneration, enrichment planting, plantations, agroforestry and various soil and water conservation techniques are all used in forest landscape restoration.

In Tanzania, techniques already in use include plantations, natural regeneration, agroforestry and various soil and water conservation techniques (Table 9). Plantations are too restricted in extent to provide sustainable livelihoods and environmental services for the large land areas demanding restoration, while assisted natural regeneration and enrichment planting have been tried only in research activities. Several reports have indicated that natural regeneration through active involvement of local communities promoted under PFM, and supported by the new forestry legislation and programme, is by far the most promising option for restoration of the large areas of degraded land in Tanzania (see Table 9). Community-Based Forest Management (CBFM) is regarded as the most appropriate way to achieve forest landscape restoration and expected to be successful because local communities are allocated clear forest land rights, and traditional knowledge and practices are taken into account.

Table 9. Technologies for rehabilitation and/or restoration of degraded land in Tanzania

Intervention	Method/Technology	Source
Natural regeneration	*Ngitilis*, Participatory Forest Management	MNTR (2008) and Monela et al. (2005)
Assisted natural regeneration	*Ngitilis*	Monela et al. (2005)
Fire	Not noticed	
Enrichment planting	*Ngitilis*, homegardens and parklands	
Plantations	Woodlots, state and private	Chamshama (2011)
Agroforestry	Homegardens, parklands, rotational fallows, trees on farm (for some traditional agroecosystems)	Khumalo et al. (2012)
Soil and water conservation	Ngoros	Khumalo et al. (2012) and MNRT (2008)

The practices assessed for Tanzania in this study include rotational woodlots, the Ngitili system, and different methods of natural forest management under PFM or Community-Based Natural Resource Management (CBNRM).

The Joint or Participatory Forest Management (JFM/PFM)

According to MNRT (2008), JFM was conceived largely as a means to secure local support for forest conservation and followed similar strategies in other parts of the world, such as India and Nepal. Gologolo and Kipumbwi Forest Reserves in Tanga Region and Udzungwa Forest Reserve in Iringa Region were some of the early initiatives of JFM development. These initiatives were extended to catchment forests in Tanga, Arusha, Morogoro and Kilimanjaro regions and mangroves along Tanzania's coast from Tanga to Mtwara as part of implementation of the Management of Natural Resources Programme (MNRP). The goal of MNRP was *"Natural resources contributed on sustainable basis towards reduced income poverty, vulnerability amongst the poorest groups and improved quality of life and social well-being in Tanzania"* (MNRT, 2008). The objective was: Increased benefits to rural communities based on sustainable natural resource management in Tanzania

Despite the rather considerable investments in PFM both from the Government of Tanzania and its development partners, there have been remarkably few studies that have attempted to independently assess the impact of PFM under different conditions. A total of 13 forests have been sampled and showed increases in basal area and volume in sites managed under both JFM and CBFM and declines for both of these variables in forests under government or open access management (Figure 2a and b). There were also declines in number of stems ha^{-1} in forests managed under CBFM, and increases in JFM areas and forests under exclusive state management (Figure 2c). Although the data comes from different areas of Tanzania and different ecological conditions, they tend to suggest that forest areas managed under JFM and CBFM are recovering compared with forests managed by government alone or under open access regimes.

Pfliegner and Moshi (2007) compared three matched pairs of similar forests under JFM and state management. Results showed that forests under JFM have higher numbers of live and naturally dead trees, poles and fewer cut timber trees compared with forests managed exclusively by the State (Figure 3a - c). The average number of trees was 13.8 and 9.2 in joint and non-joint forest management plots, respectively; average diameters of standing trees were 28.4 and 22.9 cm, respectively; and average heights of standing trees were 13.3 and 9.9 m, respectively (Figure 3a - c). Forests under JFM also had 68% fewer freshly cut timber trees than in non-joint forest management areas, whereas incidences of freshly cut trees for poles were 70% less frequent in the former than in the latter. Similarly, there were almost 34% more live timber trees, 45% more live poles, and more than 55% more withies recorded in JFM areas, and lower incidences of freshly cut poles and withies.

Overall, drawing on these studies, the evidence would suggest that when forest management responsibilities are fully devolved (as with CBFM), there are substantial improvements in forest condition and reduced forest disturbance. The conclusions from the studies reviewed above are less clear regarding the effectiveness of forestry co-management (or JFM) in terms of delivering improved forest management. This is an area that will require further study in the future.

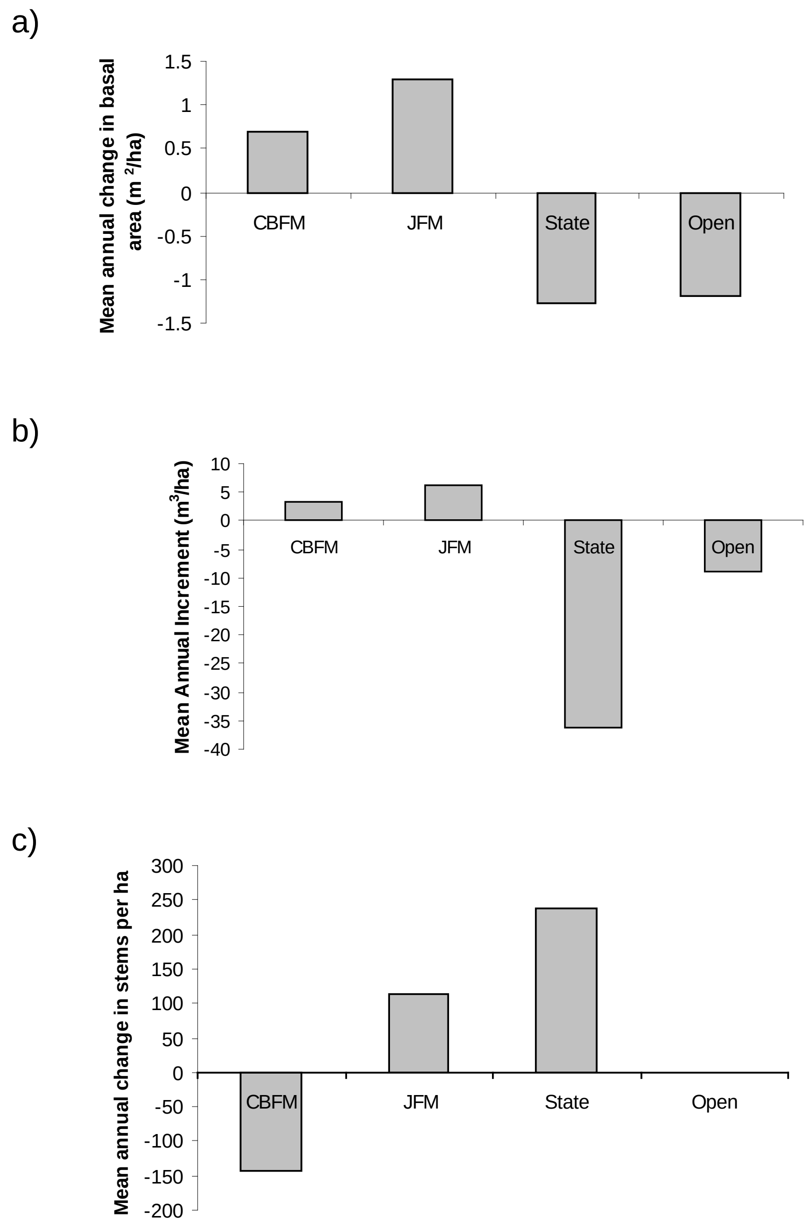

Figure 2. Mean annual changes in growth characteristics in 13 forests under different management and ownership regimes: (8 CBFM, 2 JFM, 1 Local Government management and 1 open access areas) - (a) Mean annual change in basal area, (b) Mean annual volume increment and (c) Mean annual change in stems per ha (source: Blomley et al., 2008)

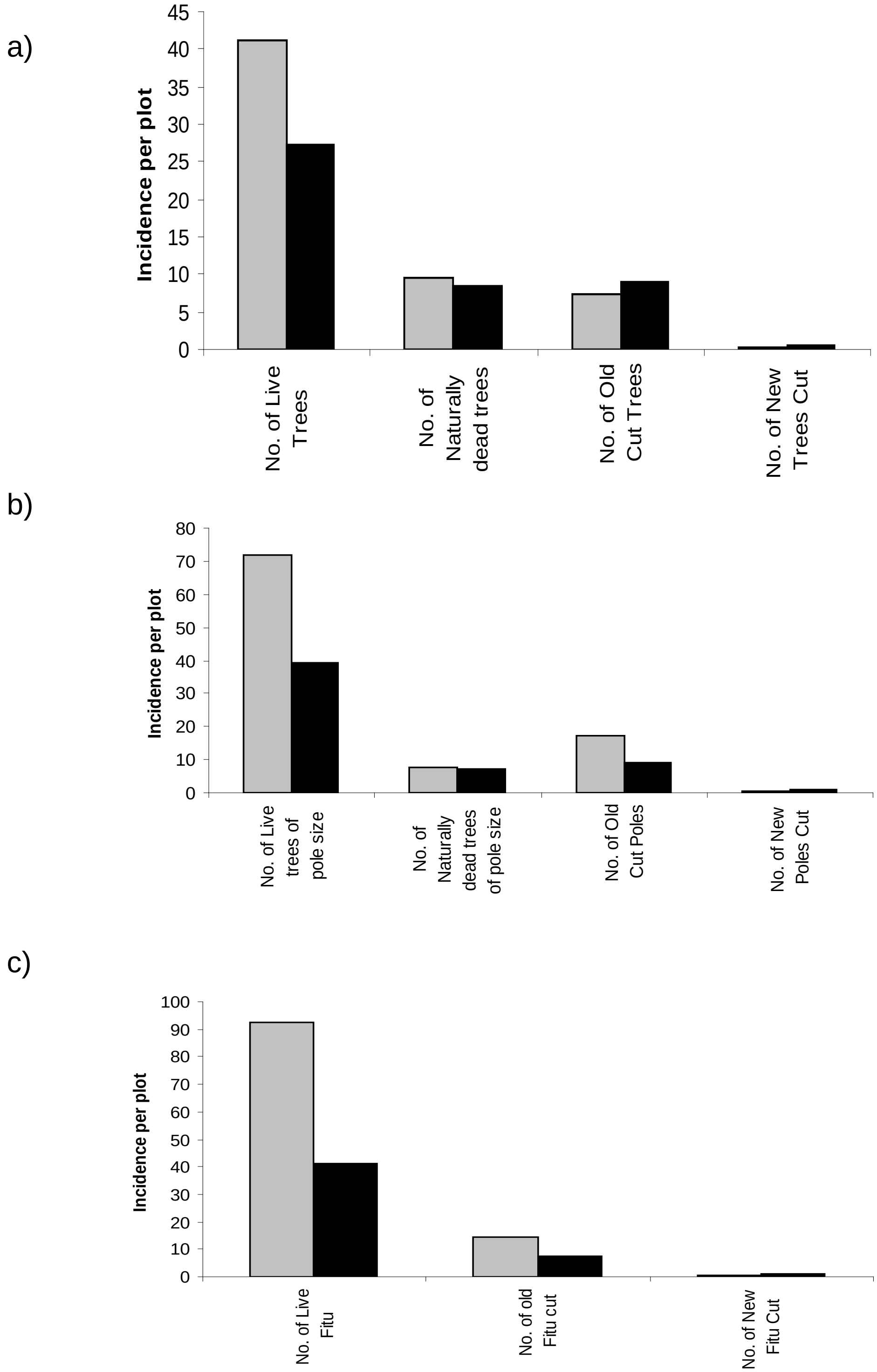

Figure 3. Disturbance characteristics for three JFM and three non-JFM forests in Morogoro Rural District: (a) cutting of trees suitable for timber, (b) cutting of trees and shrubs suitable for poles and (c) cutting of shrubs suitable as withies. Grey bars = JFM forest sites, and Black bars = non-JFM forest sites (source: Blomley et al., 2008)

The *Ngitili* System

In an *Ngitili* system, vegetation and trees are nurtured on fallow land during the five-month-long rainy season. By mutual agreement of the community, *Ngitili* land is protected from grazing animals so that fodder is available during drier months when fodder for animals is in short supply. As opposed to the traditional *Ngitili*, some have now been modified or improved by enrichment planting with fast growing soil improving exotic species (Figure 4).

Figure 4. Photos showing example of naturally regenerated (A) and planted (B) Ngitili in Shinyanga rural area, Tanzania (Courtesy: Chirwa, 2012)

Different types of *Ngitilis* can be found in Shinyanga depending on the ownership and management type. Common *Ngitili* ownership includes communal, private and institutional *Ngitilis*.

Communal ownership - *Ngitili* under communal ownership by a village or a group of community members are common in most villages. Communal *Ngitilis* are established by demarcating an area within no-man's land or by conjoining several individual plots and subjecting the area to common rules and regulations for grazing and grass cutting seasons. Management of the resource is controlled by the elders of the community. More recently, the environmental committees have taken over the management of village *Ngitilis* in some villages. Communal *Ngitilis* are usually larger than individual *Ngitilis*, ranging from 10 to 500 ha (Otsyina et al., 2008).

Individual ownership - Many households also have privately owned *Ngitili*, usually managed by the individual households and handed down through generations. These households maintain the right of access to the *Ngitilis* and normally consent when neighbours or other people request grazing rights. Collection of fuelwood or cutting trees, usually, involves a cash payment. Although declared as the most effective system of natural resource management, individually owned *Ngitilis* were the most threatened system of ownership, usually subjected to fragmentation because of increasing land shortage or being purchased by the more well-off households. Sizes of individual *Ngitilis* range from 0.25 to 200 ha (Otsyina et al., 2008).

Institutional ownership - In almost every community, institutions, such as school and religious organizations (the church) have established their own *Ngitilis*, most with exotic species that provide tree products, such as timber, charcoal and poles for construction. Most of these were established as woodlots and later turned into *Ngitilis*.

Rotational woodlots

One of the early agroforestry interventions tested in the Shinyanga and Tabora areas was the introduction of rotational woodlots (see details under description of the technologies) to address the acute shortage of domestic fuelwood and for curing tobacco. This, it was assumed, would reduce over-reliance on natural forest and woodland resources that would otherwise lead to unsustainable utilization of unprotected forests in public lands in Tanzania.

Rotational woodlots were developed as an introduction of trees and shrubs into existing crop and pasture production systems with a systematic management in order to address the severe shortage of fuelwood, inadequate fodder supply, increasing deforestation, land and environment degradation and chronic food deficiency (Otsyina and Asenga 1993). Essentially, this is a replacement of the traditional shifting cultivation systems that have long fallow periods with intensive short duration fallows. The technology involves growing of trees and crops in three inter-related phases: (i) an initial tree establishment phase in which trees are intercropped with crops, (ii) a tree fallow phase and (iii) a cropping phase after tree harvest (Figure 5). Each of the phases can be, specifically, managed to provide products and services of economic, social and environmental values. The first phase lasts for 2 to 3 years and simulates the `*Taungya*' system of establishing forest plantations. During this phase, trees benefit from land preparation, weeding and other annual crop management operations. Cropping is discontinued when the tree roots and canopy are fully developed and no longer permit economic yields of crops. During the tree fallow phase, which may last for 2 to 4 years, the trees could be managed as *Ngitili* or fodder banks.

Some of the tree species that have been tested in woodlots in western Tanzania (Tabora/Shinyanga) include *Acacia crassicarpa* A.Cunn ex Benth., *Acacia leptocarpa* A.Cunn ex Benth., *Acacia julifera* Benth., *Acacia mangium* Willd., *Acacia nilotica* (L.) Willd. Ex Del. *Acacia polyacantha* Willd., *Eucalyptus* spp., *Gliricidia sepium* (Jacq.) Kunth ex Walp., *Leucaena leucocephala* (Lam.) De Wit and *Senna siamea* (Lam.) Irwin & Barneby. Studies in Morogoro, Tabora and Shinyanga showed that wood yields for the above mentioned species can range from 20 to 90 tons ha^{-1} in four to five years. The maximum harvest may meet household demand for 7-10 years, thereby, reducing harvesting pressure from natural forests (R. Otsyina, personal communication)

Productivity, biodiversity and dominant species in *Ngitilis* and Woodlots

Analyses by Otsyina and Asenga (1994) and Monela et al. (2005) have shown that individual *Ngitilis* are well defined and of better quality in terms of productivity/wood stocking and biodiversity compared to communal *Ngitilis*. Superiority of individual compared to communal *Ngitilis* has also been shown for fodder dry matter yield.

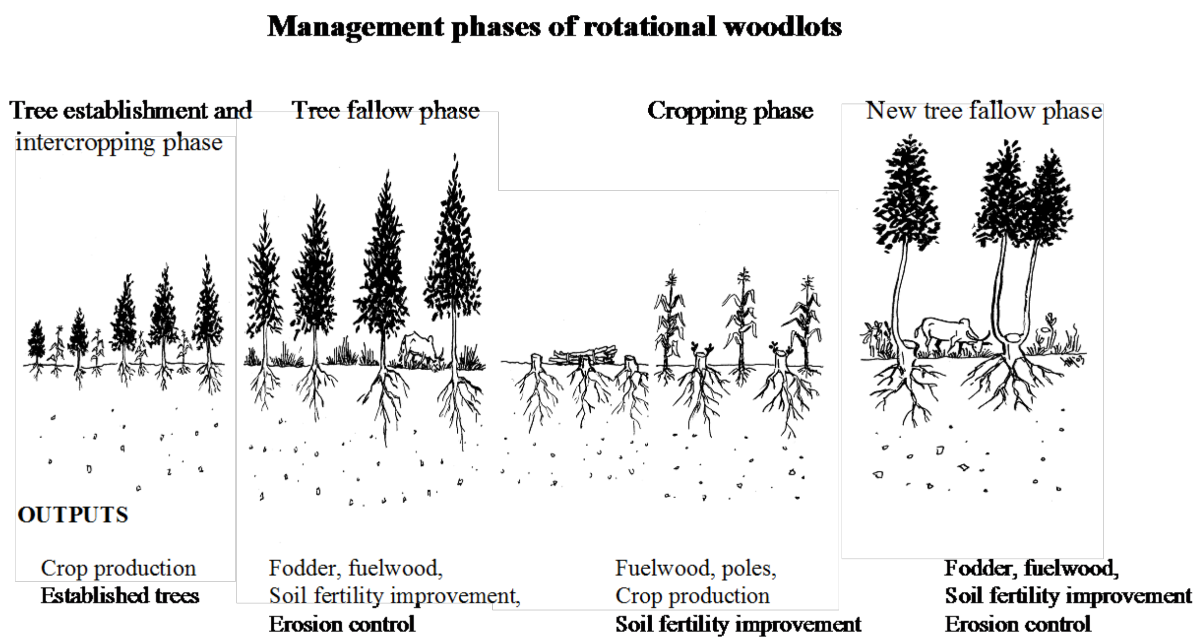

Figure 5. Successive phases of the rotational woodlots technology being tested in northwestern Tanzania. The approximate length of each phase is 2-3 years (source: Otsyina et al., 1996)

The average number of stems (N) on *Ngitilis* can range from 380 to 1753 ha^{-1} (Table 10). The number of stems was highest in Kahama and lowest in Shinyanga. The difference in the number of stems between the two studies could be attributed to factors, such as age of the stand, species, rainfall regimes and management. These parameters contribute to the biomass production of *Ngitilis*. Biomass values follow a similar trend ranging from 1.35 tons ha^{-1} in Shinyanga to 29.50 tons ha^{-1} in Meatu with an average of 25.43 tons ha-1 (Table 11).

Table 10. Stand characteristics of *Ngitilis* and woodlots in Shinyanga

District	No. of stems (ha^{-1})	Basal area (m^2 ha^{-1})	Volume of wood (m3 ha^{-1})	Biomass (tons ha^{-1})
Ngitilis				
Kahama	1,753.86	8.86	31.51	15.75
Meatu	1,485.42	17.13	59.00	29.50
Shinyanga	380.38	1.31	2.69	1.35
Mean	1,397.30	14.79	50.86	25.43
Woodlots				
Kahama	1,359.58	16.37	60.48	30.24
Meatu	1,014.61	11.16	32.55	16.28
Shinyanga	1,203.93	12.64	60.40	30.20
Mean	1,197.20	13.09	54.85	27.42

Source: Otsyina et al. (2008).

Planted woodlots have shown very similar stand characteristics among districts. The number of stems ranged from 1,014 to 1,359 ha^{-1} in Meatu and Kahama, respectively, while biomass values ranged from 16 to 30 tons ha^{-1} with an average of 27.42 tons ha^{-1}. Total biomass from woodlots was higher than biomass from *Ngitilis* due to species differences and management regimes. Common species used on the woodlots include L. *leucocephala*, S. *siamea, Azadiracta indica* A. Juss., *Melia azedarach* L., *Gmelina aborea* Roxb., *Eucalyptus* spp. It must be noted that these are exotic species. Interestingly, there seemed to be differences in the estimates of number of stems, basal areas and volume of wood between Otsyina et al. (2008) (Table 10) and Monela et al. (2005) (Table 11)). This could be attributed to the period when sampling took place (i.e. 2005 and 2008).

Table 11. Stand parameters by district for the surveyed *Ngitilis* in Shinyanga Region

District	No. of stems (ha^{-1})	Basal area (m^2 ha^{-1})	Volume of wood (m^3 ha^{-1})	Shannon-Wiener index of diversity (H')	Index of dominance (C)
Kahama	6,553	5.76	19.60	3.67	0.04
Shinyanga Rural	3,232	3.84	10.08	3.51	0.04
Bukombe	2,508	5.86	27.02	3.18	0.08
Bariadi	2,958	3.87	9.18	2.84	0.11
Maswa	2,602	4.56	10.29	2.54	0.11
Meatu	1,964	5.81	14.18	2.20	0.16
Shinyanga Urban	4253	3.394	6.623	1.874	0.292

* Source: Monela *et al*. *(*2005).

The dominant tress species found in *Ngitilis* varied between districts and vegetation types (Table 12). With exception of re-growth in the miombo woodlands of Shinyanga, and Bukombe districts, the *Ngitilis* in the rest of districts are dominated by acacia species. The dominant species are *Acacia drepanolobium* Harms ex Sjöstedt, A. kirkii Oliv., A. *mellifera* (Vahl) benth., A. *polyacantha*, A. *senegal* (L.) Willd., A. *seyal* Del. var. *fistula* (Schweinf.) Oliv., A. *sieberiana* DC. *Acacia tortilis* (Forssk.) Hayne and A. *tanganyikensis* Brenan. Other non-acacia species are *Albizia harveyi* E. Fourn., *Combretum zeyheri* Sond., *Commiphora africana* (A. Rich.) Engl., *Cordia sinensis* Lam., *Dalbergia melanoxylon* Guill. ex Perr., *Diplorhynchus condylocarpon* (Müll. Arg.) Pichon and *Pterocarpus angolensis* DC. The acacia species are pioneer species and, thus, their dominance suggests that the woodlands are recovering.

Table 12. Harvested tree species in the surveyed *Ngitilis* of Shinyanga region

Bukombe District	Maswa District	Bariadi District
Brachystergia boehmii Taub.	A. *tortilis*	A. *polyacantha*
P. angolensis	*Terminalia stuhlmanii* Engl.	A. *nilotica* subsp. *indica* (Benth.) Brenan
Julbernardia globiflora (Benth.) Troupin	A. *polyacantha*	C. *caerulea*
Brachystegia spiciformis Benth.	A. *seyal* var. *fistula*	O. *trichocarpum*
Vitex doniana Sweet	*Ziziphus mucronata* Willd.	D. *melanoxylon*
Burkea africana Hook.	A. *mellifera*	A. *harveyi*
Kigelia africana (Lam.) Benth.	*Diospyros fischeri* Gürke	D. *fischeri*
Hymenocardia acida Tul.	*Balanites aegyptiaca* (L.) Del.	L. *humilis*
Albizia versicolor Welw. ex Oliv.	A. *drepanolobium*	A. *drepanolobium*
Combretum adenogonium Steud. ex A. Rich.	*Catunaregam spinosa* (Thunb.) Tirveng.	
Combretum molle R. Br. ex G. Don	C. *africana*	**Shinyanga Rural Disrict**
Annona senegalensis Pers.	C. *sinensis*	B. *spiciformis*
Pseudolachnostylis maprounefolia Pax	*Grewia similes* K. Schum.	*Cassipourea mollis* (R.E.Fr.) Alston
Multidentia crassa (Hiern) Bridson & Verdc.	*Commiphora caerulea* Burtt	*Ochna holstii* Engl.
Hexalobus monopetalus (A. Rich.) Engl. & Diels	*Lannea humilis* (Oliv.) Engl.	C. *molle*
Xylopia antunesii Engl. & Diels		*Zanha africana* (Radlk.) Exell
Terminalia sericea Burch. ex DC.	**Meatu District**	*Margaritaria discoidea* (Baill.) G.L.Webster
A. *harveyi*	A. *mellifera*	D. *condylocarpon*
Parinari curatellifolia Planch. ex Benth.	A. *tortilis*	*Albizia tanganyikensis* Baker f.
Vitex mombassae Vatke	C. *africana*	
	A. *senegal*	
Kahama District	C. *sinensis*	
C. *zeyheri*		
P. *angolensis*	**Shinyanga Urban District**	
T. *sericea*	A. *sieberiana*	
Crossopteryx febrigua (Afzel. ex G. Don) Benth.	*Ormocapum trichocarpum* (Taub.) Engl.	
Combretum psidioides Welw.		

Source: Monela et al. (2005).

Common species used in the woodlots include L. *leucocephala*, S. *siamea*, A. *indica*, M. *azedarach*, G. *aborea* and *Eucalyptus* spp. However, D. *cinerea* exhibited the highest number of seedlings ha^{-1} SPH (233) followed by *O. trichocarpum* (101) (Table 13). Thus, the *Brachystegia* species are not common so far, possibly, suggesting early stages of succession in the *Ngitilis*.

Table 13. The ten trees species with the highest regeneration in *Ngitilis* in Shinyanga region

Species	Seedlings ha^{-1} (SPH)
D. cinerea	233
O. trichocarpum	101
C. Africana	71
Maerua parvifolia Pax	71
M. discoidea	51
A. drepanalobium	46
Catunaregum spinosa Thunb.	36
C. molle	30
Mayternus senegalensis (Lam.) Exell	30
C. zeyheri	30

Source: Monela et al. (2005)

CHAPTER 4 Successful practices and pre-conditions for up-scaling

EVALUATION OF RESTORATION PRACTICES

The restoration practices take different forms in the different countries depending on the needs. The main forms include protection of the area through exclosures (e.g. *Ngitilis*) where natural regeneration or assisted regeneration can be promoted. However, most rehabilitation of natural woodlands in areas where PFM has been carried out has been through natural regeneration with coppicing whereas new afforestation is undertaken in the form of artificial regeneration through tree planting with fast growing species or multipurpose trees, if it is in the farmers' fields. Plantations and woodlots seem to be promoted, mainly, through government and private sector and development partners with woodlots, mostly, targeted for the production of wood for energy and construction purposes.

Restoration through CBNRM Approach

Forestry activities have been very successful in Tanzania through PFM (MNRT, 2008). Five projects in different part of Tanzania had their activities supporting CBFM or JFM in woodlands where restoration and/or rehabilitation activities were conducted (Table 14). There was relatively rapid spread of both CBFM and JFM over the past decade (Figure 6). Until 2008, the area of forest under the two management approaches was fairly evenly matched. However, given the growing interest in CBFM coupled with some of the administrative obstacles associated with the formalisation and benefit sharing in JFM, CBFM (2.35 million ha) has now overtaken JFM (1.77 million ha) in terms of forest coverage. The areas covered include Iringa, Babati, Kiteto, Silimanjiro, Singida, Lushoto, Handeni, Mwanga, Muheza, Korogwe and Shinyanga. The more recent expansion of PFM into miombo and acacia woodland habitats may have been due to the increased emphasis placed by both the Government of Tanzania and its development partners on achieving poverty reduction objectives. However, this success is not apparent in the other countries of EA where devolution of powers on natural resource management has not been fully implemented (Alden-Wily, 2002).

Table 14. Bilateral PFM support projects operational between 1993 – 2000

Project name	District	Donor	Main activity
MEMA	Iringa	Denmark	Facilitating CBFM in miombo woodlands and JFM in highland montane forests
LAMP	Babati, Kiteto, Simanjiro, Singida	Sweden	Piloting CBFM in dryland woodlands
DNRMP	Lushoto, Handeni and Mwanga	Germany	CBFM and JFM in both highland and lowland forests
EUCAMP	Muheza, Korogwe and Handeni	Finland	Supporting the conservation of high biodiversity forests
HASHI	Shinyanga	Norway	Supporting rehabilitation of dryland woodlands through restoring traditional *Ngitili* practices of dry season reservation

Source: MNRT (2008).

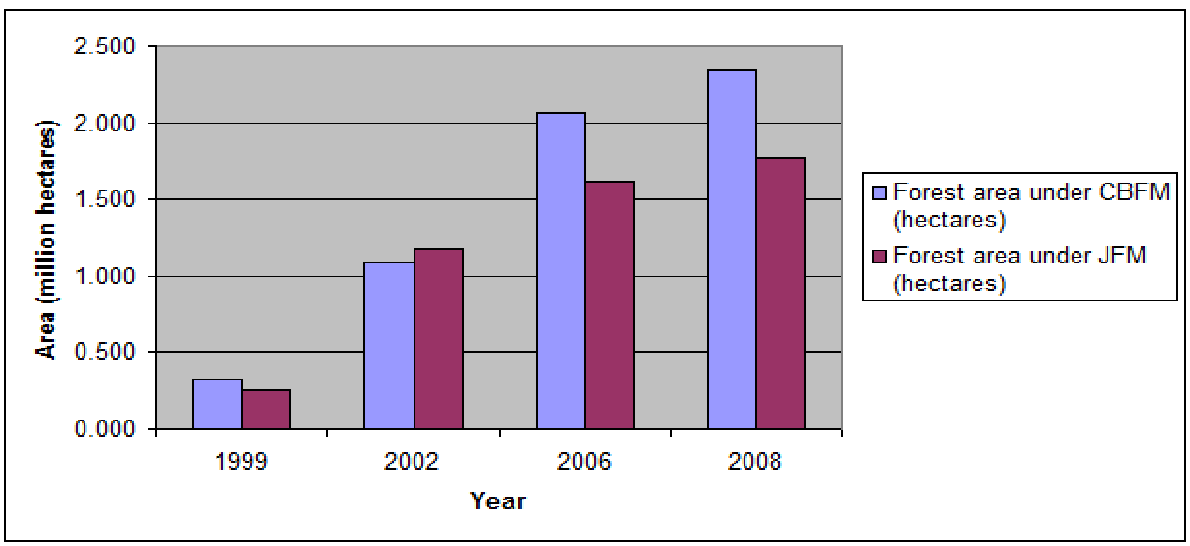

Figure 6. Spread of CBFM and JFM from 1999 - 2008 (source: MNRT, 2008)

Restoration through exclosures and woodlots

The most widely reported examples of restoration through exclosures (*Ngitilis*) and woodlots in EA are found in western Tanzania where it has proven very successful. Exclosures are also reportedly used in northern parts (Mengistu et al., 2005a and b; Birhane et al., 2004, 2006; Mekuria, 2007; Teketay et al., 2010) and Borana and Somali Region Pastoral Areas of Ethiopia (Zeleke, 2009). Similarly, farm forest, a form of woodlots, has also been promoted in Uganda (Chamshama, 2011) as part of the mitigation measures to climate change.

Ngitilis and woodlots

According to R. Otsyina (personal communication), an accurate number and area covered by *Ngitilis* and other interventions in Shinyanga is not known. Various estimations have been made by community members and researchers. For example, Kaale et al. (2003) estimated about 78,122 ha (46,593 and 34,206 individual and communal *Ngitilis*) of *Ngitilis* from 172 villages in 2001 while Monela et al. (2005) estimated about 500,000 ha from 833 villages. Some have estimated that there are currently between 500,000 and 600,000 ha of conserved areas under all interventions (Otsyina et al., 2008; Figure 7). Many of the woodlots originally established for alternate cropping and wood production are also being managed as *Ngitilis*.

As one of the nine Community-Based REDD Mechanisms for Sustainable Forest Management REDD pilot projects implemented in Semi-Arid Areas in Tanzania, the Shinyanga *Ngitili* and woodlot systems give an insight into future directions of connecting farmers to CDM mechanisms in EA. The project is implemented in Shinyanga Rural and Kahama Districts of Shinyanga Region by a consortium comprising Tanzania Traditional Energy Development and Environment Organization (TATEDO) and Development Associates (DASS) in partnership with Natural Forest Resource and Agroforestry Centre (NAFRAC) and district councils. The overall goal of the project is to reduce greenhouse gas (GHG) emissions through sustainable forest management and carbon market incentives. This particular project focuses on private forest owners at the community level to explore mechanisms for their involvement in REDD process. Its purpose is to assist 250 *Ngitili* owners to establish a robust local institutional framework that effectively manages the restored *Ngitilis* to capture benefits arising from REDD. Some of the management practices directly related to forest restoration include:

- facilitation of establishment of woodlots and tree planting as interventions to reduce degradation and deforestation in *Ngitilis*;
- *Ngitilis* enrichment planting; and
- tree singling.

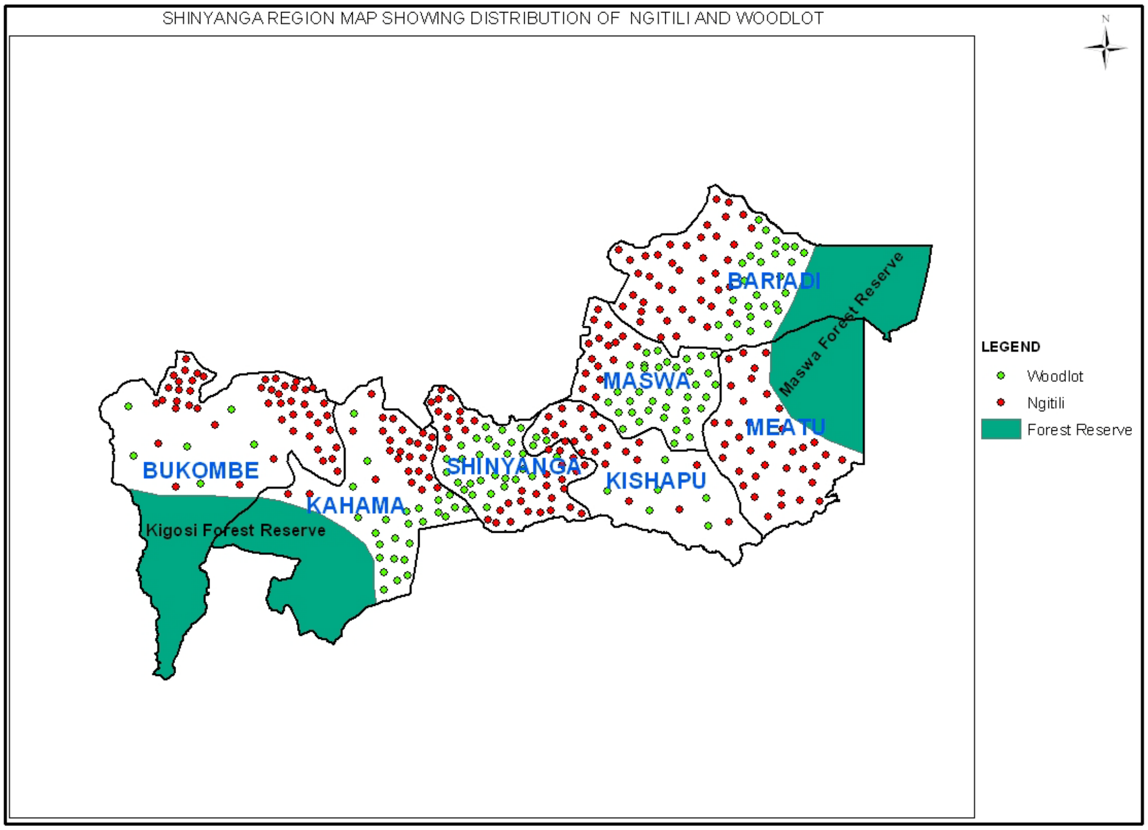

Figure 7. Map showing the distribution of *Ngitilis* and Woodlots in Shinyanga (source: Otsyina et al., 2008)

In the *Ngitilis*, Otsyina et al. (2008) estimated biomass production of 25.43 tons ha^{-1} from trees, 3.6 tons ha^{-1} from grasses and forbs, 2.32 tons ha^{-1} from litter and 8.61 tons ha^{-1} of soil carbon (Table 15). The woodlots, with higher tree densities were more productive with the corresponding values of 27.42 tons ha^{-1} from trees, 2.0 tons ha^{-1} from grasses and forbs, 2.71 tons ha^{-1} from litter, 6.86 tons ha^{-1} from roots and 8.41 tons ha^{-1} of soil carbon. Assuming total area of about 500,000 ha on *Ngitilis* and 1,500 ha under woodlots and other agroforestry systems, a total biomass of 23,143,671 tons from *Ngitilis* and 23,214,752 tons of dry matter were estimated to be standing. This translated to about 11,607,376 tons of carbon (using a conversion factor of 0.5 dry matter to carbon ratio) and about 42,599,070 tons of carbon dioxide equivalents. Using average voluntary carbon market rates of US$ 5.0 per ton of carbon dioxide, Otsyina et al. (2008) estimated the total value of the system at US$ 212,995,350.00.

Table 15. Carbon stocks and values from all pools in *Ngitilis* and woodlots

Source/Pool	Mean biomass (tons ha^{-1})	Area covered (ha)	Total biomass (tons ha^{-1})	Carbon (tons ha^{-1})	CO_2 Equivalent	Monetary value (US$)
			NGITILIS			
Standing biomass (trees)	25.43	500,000	12,715,127	6,357,563	23,332,257	116,661,286
Below ground* (Roots)	6.36	500,000	3,178,782	1,589,391	5,833,064	29,165,322
Grasses and forbs	3.57	500,000	1,785,121	892,561	3,275,697	16,378,486
Litter fraction	2.32	500,000	1,157,823	578,912	2,124,606	10,623,028
Soil Carbon	8.61	500,000	4,306,818	2,153,409	7,903,011	39,515,057
SUB TOTAL			**23,143,671**	**11,571,835**	**42,468,636**	**212,343,179**
			WOODLOTS			
Standing biomass (trees)	27.42	1500	41,134	20,567	75,482	377,408
Below ground* (Roots)	6.86	1500	10,284	5,142	18,870	94,352
Grasses and forbs	1.99	1500	2,985	1,493	5,478	27,388
Litter fraction	2.71	1500	4,058	2,029	7,446	37,231
Soil Carbon	8.41	1,500	12,620	6,310	23,159	115,793
SUB TOTAL			**71,081**	**35,541**	**130,434**	**652,171**
GRAND TOTAL			**23,214,752**	**11,607,376**	**42,599,070**	**212,995,350**

Source: Otsyina et al. (2008); * Root biomass estimated at 25% of tree biomass.

Exclosures in Ethiopia

Borana pastoralists' traditional exclosures were called *seera yabbii* (literally 'protected grazing for calves') (Zeleke, 2009). They were relatively small, around 10 hectares or less, and had a very specific purpose - to conserve pasture or put aside a section of the rangeland for milking cows, calves and sick animals during the dry season/times of drought. They have mostly been replaced through the introduction of *kallos*, which are larger, fenced exclosures with different functions. These are semi-private/communal *kallos* since although they are organised on the basis of a community or group of communities, they are fenced, either physically (using thorn bush) or socially (through by-law or community agreement), and, therefore, exclude some people from what was previously open rangeland.

There are different types of semi-private/communal *kallos*, and their uses, establishment and management vary and can be categorized as: (i) community-initiated, (ii) NGO-initiated or facilitated and (iii) government-initiated/facilitated. There are also private exclosures (*Dhunffaa*), which are for commercial livestock fattening/marketing enterprises. They are allowed both traditionally - as long as the applicant goes through the elder system and secures elders' approval - or by the local authority. The practice has grown whereby individuals fence a large area, purportedly for crop cultivation, but, then, plant crops on a small part of the land and keep the rest as pasture for rent or for hay production and sale. This type of exclosure is expanding all over the Borana lowland. Most of these 'farmlands' are located in the flat valley bottoms, taking the most productive and fertile land from the common range.

Finally, there are cooperative exclosures (*Weldaa*), which were first established in the 1980s by Southern Rangelands Development Unit (SORDU) with the main purpose of generating income for the cooperative members by providing access to grazing for livestock traders. There are reportedly five big ranches (two of which are cooperative ranches) in the Borana rangelands currently, occupying around 33,000 ha. Only members and those that pay a fee are allowed to use the grazing in the ranches. Earlier, these were open areas, including important grazing and watering resources for the Borana pastoral system.

In Somali region, there are broadly, four types of '*seero'* (exclosure), i.e. private, government, communal and/or NGO-supported (in some areas) and owned by cooperatives. Two types of private exclosures are recognized, namely "*sera*" - within an existing farm - and "*beer*" -outside the farm.

PRECONDITIONS FOR UP-SCALING

According to Desanker and Magadza (2001), the most promising adaptation strategies to declining tree resources in Sub-Saharan African countries include natural regeneration of local species, sustainable forest management and community-based natural resources management. However, the success of such strategies generally depends on the ability of local people to exercise power to inventory and manage local resources in systems of CBNRM. Most of the National Appropriate Mitigation Actions (NAMAs) in EA identified agricultural expansion and overgrazing as some of the causes of deforestation. Indeed, some of the factors that have contributed to forest degradation highlighted in Ethiopia, Rwanda and Uganda were frequent drought (Table 16). The different countries seem to have different forms of practices for restoration. For example, Tanzania and Ethiopia seem to promote exclosures and natural regeneration in areas associated with overgrazing. Artificial regeneration is advocated for community woodlots in Tanzania and Rwanda, reforestation of degraded hill areas in Ethiopia and farm forests in Uganda (Table 16).

Table 16. Regional and national approaches and programmes in Eastern Africa, and the recommended practices for restoration

Country	Type and cause of degradation	Objectives and/or activities for restoration	Potential Practices for restoration
Tanzania	Agricultural expansion, human settlements and population increase; Overgrazing Firewood and charcoal production; Timber extraction; Infrastructure development, Bio-fuel production	Collaborative forest management • Ensured ecosystem stability through conservation of forest biodiversity, water catchment and soil fertility • National wide tree planting campaign • Participatory forest management	Develop community based approaches Forest fire management Artificial regeneration (Afforestation in degraded lands) & MPTs community woodlots Natural forest regeneration
Ethiopia	Agricultural expansion, land degradation, soil erosion, deforestation, loss of biodiversity, desertification, recurrent drought,	Community Based Rehabilitation of Degraded Eco-Systems in Selected Parts of Ethiopia Reforestation of Hill Areas in the Northern Parts of Ethiopia Promotion of Agroforestry Systems and Home-garden Agriculture	Natural regeneration Artificial regeneration (reforestations) Agroforestry
Uganda	Frequent droughts and floods Increasing population Poor agricultural practices	Farm forest Promote the cultivation of forest medicinal and edible plant species	Artificial regeneration
Rwanda	High degradation of arable land due to erosion Desertification, Degradation of forests Prolonged seasonal drought	Develop alternative sources of wood energy Preparation of a forest development plan?	Agroforestry Artificial regeneration

CBNRM Approach

In Tanzania and Ethiopia, community-based approach seems to be the way that is promoted for implementing activities that address conservation of forest biodiversity, water catchment and soil fertility. In Ethiopia, this is even extended to community-based rehabilitation of degraded ecosystems. An example of a successful forest landscape restoration is the *Ngitili* system of agro-pastoral communities in Shinyanga Region. Studies have found that more than 350,000 ha of land were occupied by restored or newly established *Ngitilis*, of which about 50% was owned by groups and another 50% by individuals. Benefits from *Ngitilis* were estimated at US$ 14 per person per month, which is much higher than the average monthly spending per person in rural Tanzania (US$ 8.5). The success stories on this forest landscape restoration (e.g. *Ngitilis*) have always been associated with situations where communities were actively involved, and their interests, local knowledge and practices were taken into account. This notion is already part of the current policies and legislation in almost all sectors in Tanzania, which provide the necessary enabling environment for restoration of degraded lands. The initial positive impacts of landscape restoration provide guidance and encouragement for wider success in the future. This is, however, not the case in most of the other countries in EA where there seems to be a promotion of private tree (farm forest) planting as is the case in Uganda. Similarly, the success of PFM or JFM in Tanzania is as result of the enabling policies in place (Alden-Wily, 2002).

Artificial regeneration (tree planting) and agroforestry

Apart from promoting artificial regeneration in Agroforestry or tree-based agro-ecosystems, this is also becoming important in small scale commercialization of tree planting. However, the success of the ‘farm forests’ is because of the clear tree tenure that is in place in Uganda. Chamshama (2011) has reiterated that successful tree planting by the individuals in EA can only be achieved with clear land tenure, improved extension services and financing mechanisms and availability of high quality germplasm.

CHAPTER 5 Conclusions and recommendations

The study showed that natural regeneration, through active involvement of local communities promoted under PFM and/or collaborative forest management and supported by the new forestry legislation, is by far the most successful and promising option for restoration of the large areas of degraded land in EA. This is because local communities are allocated clear forest land rights, and traditional knowledge and management practices (e.g. *Ngitilis*) are taken into account.

Artificial regeneration through the woodlots or farm forests are prioritized in some countries for various reasons, including commercialization of tree planting in Uganda as out-growers, energy production in Rwanda and reforestation of bare hills in Ethiopia. There is also an opportunity to promote tree planting for carbon markets as is the case in Tanzania Community-Based REDD Mechanisms for Sustainable Forest Management REDD pilot projects.

Agroforestry is also recognized as an important avenue for rehabilitation of degraded areas, especially to improve soil fertility and soil conservation. This is particularly of great importance in agro-ecosystems that support food and energy production while at the same time providing other ecosystem services.

Specifically under each objective, the following were concluded and/or recommended:

EXPERIENCE FOR REHABILITATION

- Exclosures are prevalent in livestock farming areas of Tanzania and Ethiopia where they are used to encourage rehabilitation of grazing land;
- Traditional and improved agroforestry systems and technologies are used to rehabilitate land with the most common technologies being improved fallows, homegardens, boundary planting and contour hedgerows for soil conservation and improved soil fertility;
- Natural and assisted regeneration with coppicing and pollarding is the most common form of regeneration used in the region.

SUCCESSFUL TECHNOLOGIES AND PRACTICES

The successful technologies in EA include:

- exclosures for agro-pastrolists;
- agroforestry technologies: traditional homegardens, soil conservation and soil fertility enhancement;
- farm forestry in Kenya, Rwanda and Uganda; and
- CBNRM approaches.

CONDITIONS FOR UP-SCALING SUCCESSFUL TECHNOLOGIES

- In future, there is need to relook at the forest and environmental policies, e.g. in Kenya and Ethiopia, to make them more enabling to forest restoration and land rehabilitation;
- Implementation of enabling polices that promote forest and land restoration through clear land tenure and the linkage of the energy policy to forest restoration because of the overreliance on the forest resource for energy in the region;
- The need to associate the forest and land restoration/rehabilitation implementation with forest enterprise development (e.g. Farm Forestry/Out-growers) and payment of environmental services.

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