Rehabilitation of degraded forest and woodland ecosystems in Ethiopia for sustenance of livelihoods and ecosystem services

Convening lead author: Eshetu Yirdaw

Lead authors: Mulualem Tigabu, Mulugeta Lemenih, Mesele Negash, and Demel Teketay

Abstract: Deforestation in the northern part of Ethiopia has occurred for the past three millennia, while deforestation in the southern part is a relatively recent phenomenon. Hence, the rehabilitation of the vast denuded forestlands and woodlands, which are a source of ecosystem services and livelihoods to local communities, is crucial and timely. Two case studies are presented: the use of exclosures in the Alaba District and the rehabilitation of areas invaded by the alien *Prosopis* species in the Afar region. The establishment of exclosures has brought dramatic biophysical changes within few years, resulting in a substantial increase in diversity of flora and fauna, reduced soil erosion, and soil amelioration. The rehabilitation intervention has also had a positive impact on the livelihoods of local people; providing access to fodder, construction materials, and income from cattle fattening and sale of wood and grass. However, there are policy ambiguities and institutional gaps in the administration of rehabilitated lands in the country. To sustain the rehabilitation endeavour at Alaba, quintessential elements are the establishment of clearly defined land-tenure and user-right systems, the enforcement of by-laws, equitable benefit sharing, and transfer of management power to local communities. In the case of extensive areas invaded by *Prosopis* in the Afar region, adverse impacts on dryland ecosystems and on socio-economic conditions of the pastoral communities are serious concerns. The restoration intervention approach − management through utilisation − has not only hindered the spread of *Prosopis* but also provided possibilities to generate substantial income for local people by their use of the existing *Prosopis* stands. However, the lack of a clear policy direction and institutional mandate coupled with technical and financial difficulties have constrained successful management of the *Prosopis* invasion in the Afar region. Decentralisation of *Prosopis* invasion management could be a promising means of institutionalising and scaling up popular participation.

Keywords: Deforestation, degradation, rehabilitation, exclosures, livelihoods, invasive alien species, *Prosopis*, Ethiopia

18.1 Introduction

18.1.1 Deforestation and forest degradation in Ethiopia

Deforestation and forest degradation in Ethiopia have a long history with a significant spatial variation. The northern half of the country has experienced cyclic deforestation and revegetation over the past three millennia, while deforestation in the southern half is a relatively recent phenomenon (Darbyshire et al. 2003, Nyssen et al. 2004, Dessie 2007). This spatial variability has been conditioned by factors such as population growth, emergence of intensive agriculture, expansion of urban areas, and trade (Darbyshire et al. 2003, Nyssen et al. 2004). Deforestation has intensified, including the major

southward expansion, since the 1950s (Dessie 2007, Bekele 2008). Estimates of deforestation rates range from 140 000–200 000 ha per year (Reusing 1998, FAO 2010), and at present only about 12.3 million ha (11% of the land area) of forest cover remains (FAO 2010).

Agricultural land expansion and high dependence on biomass energy are the two most important direct drivers of deforestation and forest degradation in Ethiopia (Reusing 1998, WBISP 2004, EDRI 2010). With the geometric increase in population, from 12 million in 1900 to 85 million in 2010, the proportional impact of agricultural land expansion on forest cover in the country has been obvious and significant (Dessie 2007, Lemenih et al. 2008). Unlike in many other parts of the world, the shift from area expansion towards agricultural intensification has not happened in Ethiopia, making deforestation not only a past process but also a likely phenomenon into the future. Between 2000 and 2008 alone, agricultural lands expanded by about 4 million ha, and 80% of these new agricultural lands came from conversion of forestlands, woodlands, and shrublands (Federal Democratic Republic of Ethiopia2010, Brown et al. 2010). In a business-as-usual growth path, demand for agricultural land is expected to increase from 15 million ha in 2008 to 34 million ha by 2030, most of which is expected to come from forested landscapes (EDRI 2010).

New threats for the forests of Ethiopia have also emerged, including land-grabbing, biological invasion, and climate change. Large-scale land leases (land-grabbing) to foreign and domestic investors in the agricultural sector are being promoted, particularly for the production of export crops and biofuels. Several recent policy frameworks, such as the Growth and Transformation Plan (MoFED 2010), strongly advocate large-scale intensification and commercialisation of agriculture (Lavers 2012). The total amount of land leased to investors between 2004 and 2008 was about 1.2 million ha, and it will likely increase to nearly 7 million ha by 2015 (Stebek 2011). The massive land acquisition in Ethiopia is causing the clearance of thousands of hectares of natural forests and woodlands in the western and southwestern part of the country (Lavers 2012). Various types of natural forests and woodlands, ranging from moist evergreen Afromontane forest in the southwest to wooded grasslands in the western part of the country, are being cleared and replaced by commercial agriculture (cf. Stebek 2011, Gobena 2010).

Invasive alien species are another major threat to the forests of Ethiopia. Some of the plant species introduced to the country have become invasive, taking over large areas of woodlands. *Prosopis juliflora* (Sw.) DC. (hereafter referred to as *Prosopis*) is prominent among these invasive species in Ethiopia. Climate change is the third emerging threat; it affects stability and productivity of forests and woodland dynamics in Ethiopia (Dale et al. 2001), the livelihoods of forest-dependent communities, and increased forest susceptibility to fires, pests, and diseases. Climate change may also increase the spread of invasive species (McNeely 2004) and can exacerbate degradation of forest/woodland ecosystems and the people depending on these ecosystems.

The large-scale deforestation and degradation of woodlands have had significant social, economic, and environmental consequences both at local and national levels. As a consequence of deforestation, there is an acute shortage of fuelwood, construction timber, and non-timber forest products (NTFPs) in addition to disrupted ecosystem functions (soil erosion, hydrological imbalance, loss of biodiversity, etc.). Moreover, deforestation coupled with poor forest-sector development has resulted in severe industrial wood shortages, causing the country to rely mostly on imported wood and wood products. At the same time, the invasion of alien species has resulted in the decline of agricultural and livestock productivity, increasing incidence of health problems for both livestock and humans (Zeraye 2008), and exacerbated biodiversity loss (Berhanu and Tesfaye 2006, Kebede 2009).

18.1.2 Forest and woodland rehabilitation in Ethiopia

Public recognition of the need for forest conservation and management in Ethiopia dates back to AD 14th and 15th centuries (Eshetu 2000). The historic forest development pathway in Ethiopia encompasses three main phases: deforestation phase, substitution phase (use of alternative materials such as dung and crop residue for energy and stone for construction), and restoration phase. Today, Ethiopia has entered a new period of restoration practices where large areas of degraded forestlands are put under rehabilitation, although deforestation has not been abated. Both deforestation and forest-restoration processes are juxtaposed, with strong spatial segregation. The lowlands and southwestern regions of the country that host large parts of the remaining forests are still subjected to deforestation (WBIS 2004, Tadesse 2007), while the northern half of the country where forests were lost long ago is experiencing significant level of recovery (Ritler 1997, Nyssen et al. 2009). Most northern highlands of Ethiopia now have more trees and woody biomass than 100 years ago, and this positive trend has also been observed in other parts of the country during the past three decades (Ritler 1997, Jagger et al. 2005, Lemenih 2010).

Forest rehabilitation in Ethiopia includes different types of strategies and actors. Various forms of agroforestry, reforestation/afforestation, area exclosure, and woodlot development are popular strategies of restoration observed today (Teketay et al. 2010). The main actors include governmental and non-governmental agencies and the private sector. Interestingly, the forest-management approaches have evolved for the better over time. Earlier approaches focused more on reforestation/afforestation and conservation through state-centred coercive and top-down approaches, whereas more recent approaches attempt to combine participatory and decentralised approaches that include engagement of NGOs and the private sector. The management approach has also shifted in recent decades from large block industrial plantations of the 1960s and 1970s to small-scale forest plantations in the form of woodlots integrated into agricultural landscapes (Lemenih 2010).

This chapter focuses on two case studies of local-level rehabilitation endeavours: rehabilitation of degraded lands using area exclosures and the management of an area invaded by an alien tree species. The aims were to evaluate the processes and impacts of forest rehabilitation on livelihoods and ecosystem services as well as to shed light on policies and institutional arrangements that enhance and/or hinder the success and sustainability of forest rehabilitation activities in Ethiopia. For this purpose, an extensive literature survey, brief field visits to the study areas and personal experiences of the authors were used to compile the relevant data.

18.2 Policies, institutions, and governance

The major policy related to rehabilitation of degraded forest ecosystems in the country includes the issuance of the Forestry Conservation, Development, and Utilization Proclamation No. 94/1994 and the subsequent development of the country's comprehensive forest policy called Forest Development, Conservation, and Utilization Policy in 2007. The main objective of this forest policy is "to meet the forest product demands of the society and increase the contribution of forest resources to the national economy through appropriate management." Other supportive policies, strategies, and programs include: the National Action Program to Combat Desertification (NAP 1997); the Rural and Agricultural Development Policy Strategies (2002); Productive Safety Net Program (PSNP) (2003); Ethiopian Program of Adaptation on Climate Change (EPACC); Sustainable Land Management Program (SLMP) (2008–2015); Climate-Resilient Green Economy, Phase 1 (CRGE) (2011–2030).

An important policy shift in the governance of forests in general and rehabilitated forest areas in particular have also taken place by shifting from the state-centred and coercive approach (Rahmato 1994) to a more participatory and community centred approach. Except in the management of natural forests, which is predominantly managed in the form of a participatory forest-management scheme, most forest rehabilitation projects are managed by communities that are organised into various forms of community-based organisations (CBOs). CBOs develop their own by-laws (community laws) that govern their participation in the management as well as benefit sharing from the proceeds of rehabilitation activities.

Furthermore, the decentralisation policy since 1991 has transferred the responsibilities for the forestland rehabilitation and management from the federal state to the regional states. However, at the regional level, different institutional arrangements have emerged over the past 10 years. In most regional states, the respective bureaus of agriculture are responsible for forestland rehabilitation. At the federal-level, the Ministry of Agriculture and Rural Development, under its Natural Resources Directorate, is responsible for guiding and coordinating overall forest rehabilitation operations in the country. However, there still remain significant institutional gaps in the administration of rehabilitated lands in the country. These can be seen at two levels: first is the general institutional (policy and organisational) gaps at the level of national and regional states, and second is at the community level, notably related to the enforcement of community by-laws. The fact that state policies do not offer provisions for the community's power of decision-making on the management and utilisation of the rehabilitated forest resources is recognised as a major hindrance for sustainability as well as scaling up of rehabilitation efforts. Despite the active engagement of the community in establishment and successful protection of rehabilitation areas, there is persistent interference from government agencies with their protection-oriented mentality.

Generally, land belongs to the state under the Ethiopian constitution. Ownership of rehabilitated forest areas still remains ambiguous. There is no legal transfer of land management and user rights to the community other than the de facto understanding that the community owns the land. In most cases, there is no clear definition of community, i.e. there is no well-defined community boundary, and it is not clear in all cases who are the persons responsible for managing forest rehabilitation areas. Moreover, there is ambiguity on whether the trees within rehabilitation areas belong to the community managing the area or to the government, and the community is uncertain whether and when the trees can be harvested for use and, if so, by whom (Nedesa et al. 2005). There is

also stringent restriction on movement and trade of forest products, particularly when the products are from native species.

There are no clear national policies and strategies for the management of invasive alien species in general and *Prosopis* invasion in particular in Ethiopia (Anagae et al. 2004). Prosopis invasion was, however, mainstreamed as a major ecosystem threat in the Afar National Regional State (ANRS) Forestry Action Plan in 1998, where proposals have been made for concerted efforts to halt its invasion and for the need for evidence-based knowledge to guide appropriate management decisions (Tigabu and Teketay 1998). Subsequently, *Prosopis* invasion has been recognised as an emerging threat to plant biodiversity in the Forest Resource Strategy, and Draft Ethiopian National Biodiversity Strategy and Action Plan (Anagae et al. 2004). Now, *Prosopis* is declared as one of the three major invasive plant species in the country (Mwangi and Swallow 2005). However, planting *Prosopis* is still recommended for combating desertification in the National Action Plan (Anagae et al. 2004), reflecting a lack of consistent policy directions, which is attributable to the dilemma about the merits of this species and its management. There is also no clear institutional mandate for the management of alien invasive plant species, which has resulted in a lack of proactive and successful restoration interventions (Anagae et al. 2004). In recent years, the draft regulation on *Prosopis* management was prepared with the assistance of NGOs active in the area – it is awaiting ratification by the ANRS Council. The regulation outlines strategies to prevent the further spread of *Prosopis* and the rehabilitation of invaded areas; it identifies institutions mandated to lead *Prosopis* management at different levels (Getachew 2008).

Control of invasive alien species is a concern for all citizens; thus several stakeholders, both governmental and non-governmental, are involved in the concerted efforts. Research institutes provide empirical evidence supporting management interventions while governmental and non-governmental organisations provide both technical and financial supports to boost the effort to control *Prosopis* invasions, at least in a pilot phase.

Global processes, such as the World Bank carbon financing scheme, Clean Development Mechanism (CDM), REDD+, Convention on Biological Diversity (CBD), Pastoralist Livelihood Initiative (PLI), and the Millennium Development Goals are instrumental in promoting policies and programs towards forest landscape restoration in the country. In addition, national policy, such as restoring post-civil-war areas and domestic environmental and development societies are driving forest-landscape restoration in Ethiopia, particularly in the northern parts of the country.

18.3 Case studies

18.3.1 Rehabilitation of degraded lands with area exclosure

Area exclosure refers to the practice of land management whereby livestock and humans are excluded from openly accessing an area that is characterised by severe degradation (Aerts et al. 2009). The purposes of exclusion of animals and humans are to prevent further degradation of the ecosystems, advance revegetation/forest regeneration, and restore the overall ecological conditions of the areas. Area exclosure is a passive form of restoration/rehabilitation, i.e. it is primarily a natural process and human inputs are limited to offering protection against interference. For this reason, some call it a zero-management strategy for rehabilitation. The zero management makes it also the cheapest method for rehabilitation of degraded areas. Nonetheless, in a few cases, exclosures are supplemented with enrichment plantings of native and/or exotic species as well as soil and water conservation measures to speed up the recovery processes (Birhane et al. 2004, 2006, Mengistu et al. 2005a, 2005b).

Site description

For this case study, the exclosure at Alaba District (AD) is used to illustrate the rehabilitation of degraded lands in Ethiopia. AD is situated within the Great Rift Valley of Ethiopia, about 310 km south of Addis Ababa and is located at N 7°17' and E 38°06' at altitudes ranging from 1554 to 2149 m (Figure II 18.1). The AD is located within the Bilate River watershed. The annual rainfall varies from 857 to 1085 mm, and the annual mean temperature varies from 17° to 20°C. The most dominant soil of the area is andosol (Orthic) (IPMS 2007).

Considering the prevailing climate, topography, and remnant vegetation, it is highly likely that much of AD was once covered with closed dry evergreen Afromontane forests (Friis et al. 2010). Moreover, it is thought that there was abundant wildlife in the area. The conversion of forests to crop fields and pasturelands has been carried out for a long period of time in the AD and this has reduced the present forest cover to about 7% (IPMS 2005). The extensive deforestation in the area coupled with the easily erodible nature of the soil has resulted in severe land degradation, and the site is dominated by numerous gullies dissecting the landscape.

The district is inhabited by 210 243 people, distributed among 73 peasant associations. Crop cultivation, livestock rearing, and apiculture are the main

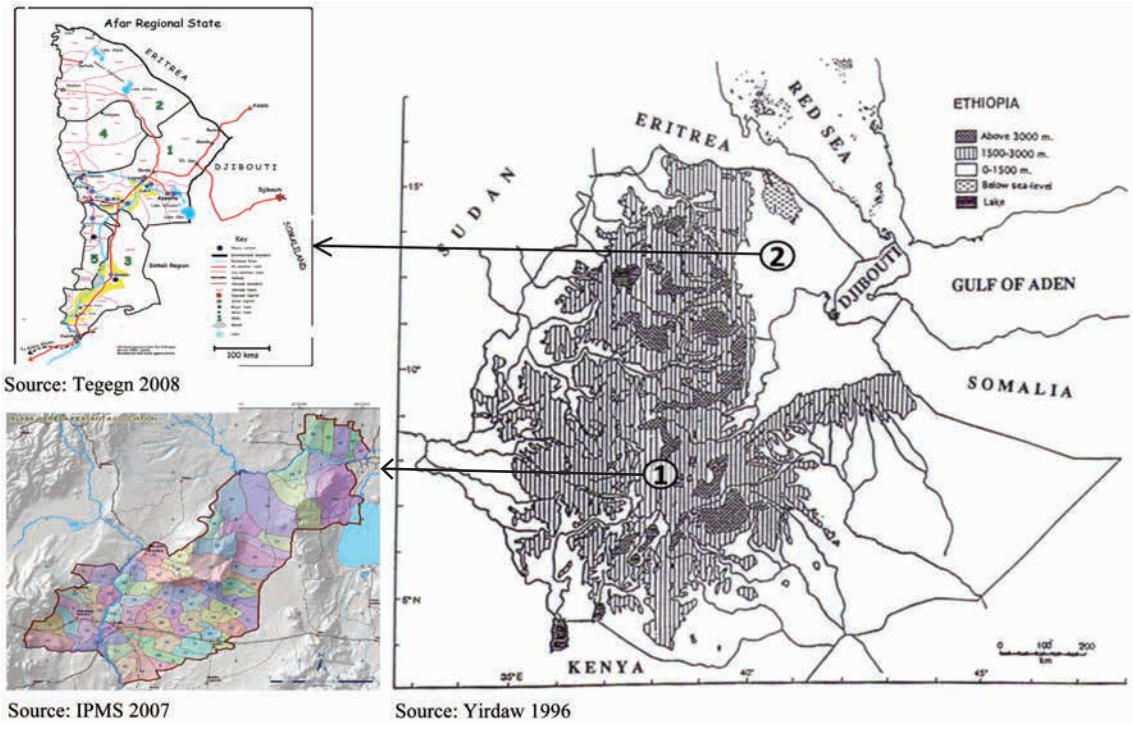

Figure II 18.1 Map of Ethiopia (right), Alaba District with 73 peasant associations (left bottom) and Afar Regional State (left top). The numbers indicate the case study sites: 1 = Alaba District, 2 = Afar Regional State. The yellow colour in the Afar Regional State map indicates areas invaded by *Prosopis*.

sources of livelihood. Maize, teff, wheat, pepper, haricot bean, sorghum, and millet are the principal agricultural crops produced in AD. In addition, livestock husbandry contributes substantially to the cash income of farm households. The forests, woodlands, and planted trees augment the livelihoods of local people by serving as a source of fuelwood, timber, and NTFPs. The livelihood sources in AD are reflected in the land-use patterns, i.e. about 76% of the land area is used for agriculture; of this, 69% is used for crop cultivation and 7% for grazing land (IPMS 2005).

Rehabilitation interventions

The initial step in the rehabilitation of denuded and degraded lands in AD was the establishment in 2009 of area exclosures on communal land by the Managing Environmental Resources to Enable Transitions (MERET) project funded by the World Food Program (WFP) and the District Office of Agriculture (DOA). The main objective of the exclosures was initially to rehabilitate/restore degraded lands previously covered by woodlands or forests for the purpose of obtaining carbon credits. WFP promised to support the endeavour financially but later withdrew from the project.

Nevertheless, the DOA pursued the task in collaboration with the district administration, surrounding Peasant Associations (PAs), local associations, particularly Energy Saving Stove Women's Association (ESWA), MERET, and some other NGOs (e.g. People in Needs, Live Voluntary International, LVI; Food for the Hungry International, FHI; and the Government Safety Net Project funded by WFP). The District Administration coordinated and mobilised the community through awareness-raising campaigns and discussions with elders and PA representatives, and it also identified households immediately surrounding the degraded sites. The DOA provided tree seedlings and grass tufts, technical advice, supervision, and networking, and it facilitated activities in the exclosures. MERET provided some incentives, for instance, wheat, as part of the food-for-work program for constructing soil and water conservation structures to reduce run-off (e.g. stone bunds, micro catchments, and tied ridges), and tree planting.

The exclosure sites were first selected by the DOA based on criteria such as extent and severity of land degradation and interest of local communities around the degraded sites. The degree of degradation was assessed on the basis of soil depth, past history of productivity, presence or absence of rock outcrops, and sensitivity to natural hazards (erosion and landslides). After site selection, rehabilitation measures at Alaba encompassed various activities, including reforestation, planting of grass tufts, building of soil erosion control structures, construction of micro catchments, and enrichment planting of

Figure II 18.2 Alaba site at the first year (left) and after four years of rehabilitation (right).
©Alaba Agricultural office

degraded areas with valuable species. These types of activities are described as major restoration interventions on degraded lands (Bongers and Tennigkeit 2010), with active involvement of various actors. 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. Naturally regenerated native tree species include *Croton macrostachyus* Hochst. ex Delile, *C. africana*, *Olea europaea* L. subsp. *cuspidata* (Wall. ex G. Don) Cif., *Dodonaea anguistifolia* L.F., and different species of *Acacia*. *Pennistum purpureum* Schumach. (elephant grass), which is a perennial fast-growing species, and *Agave sisalana* Perrine ex Engelm. were also planted for soil stabilisation and reduction of soil erosion. The survival rate of the planted trees was about 60% (Alaba MoRAD 2012). Although, the national policy strongly supports the planting of native species in exclosures (Teketay et al. 2010), exotic trees and shrubs dominated in AD as they were considered fast growing and were expected to establish well on harsh sites.

The women's association, which was organised as ESWA, was responsible for the day-to-day management of the exclosure, while the PA is responsible for overall management. The women's association is accountable to the PA. ESWA has a total of 281 members, whose homes are located around the degraded land at Chorko village in AD. The association elected its executive committee, composed of 10 persons, which is mandated to set rules and regulations on management and exit and entry, impose penalty on offenders, and resolve conflicts that may arise in the protection and management of the exclosures. The association pays salary to a guard, who is accountable to the PA and ESWA and follows up on illegal tree cutting and encroachments. Initially, a total of 281 energy-saving stoves were distributed free of charge to members of this association as part of efforts to reduce fuelwood harvest from the remnant degraded woodlands. The association members residing close to the exclosures are allowed to harvest grass through the cut-and-carry system for their own livestock and to sell to local people at lower prices. Priority is given to members of the association to buy grass for livestock fodder at a lower price than the market price.

The women (ESWA members) participated in construction and maintenance of soil and water structures, tree planting, and tending of trees and grasses planted in the exclosure (Figure II 18.2). In total, the women worked 27 days per month on the exclosure site – for 17 days they were paid through food-for-work (3 kg wheat grain/day) and the remaining 10 days they worked for free. Their contributions included collecting stones and transporting soil and grasses from other areas for construction of soil-conservation structures. The contribution of local people was 30%, while 70% was from DOA, MERET, and NGOs (Figure II 18.2). To date, a total of 7600 ha of degraded areas were restored under participatory management of exclosures in AD within 17 PAs, of which Choroko exclosure accounted for 105 ha. At Choroko alone, a total of 28 km of long bunds and trenches and 78 000 micro catchments were constructed (Alaba MoRAD 2012).

Biophysical changes of post-rehabilitation interventions

The rehabilitation interventions have resulted in dramatic biophysical changes within few years. Tree planting, coupled with the natural regeneration of native woody species from the soil seed bank and seed rain, has resulted in the formation of a young secondary forest (Figure II 18.3). The open ground is fully covered by grasses and forbs. The wild fauna, such as warthog, rabbit, hyena, and various species of birds, have been observed in the enclosed area. In general, the diversity of flora and fauna has increased substantially compared to pre-rehabilitation intervention conditions. However, although the diversity

Figure II 18.3 Local people constructing physical soil conservation structures and planting trees and grasses on degraded land at Choroko, Alaba, southern Ethiopia. ©Alaba Agricultural office

of flora has increased significantly, it is still substantially lower in diversity vis-à-vis the natural forest that once thrived in the area. Water runoff and soil erosion have been reduced significantly, due mainly to increased vegetative cover and the physical soil conservation structures, while the soil nutrient status and soil physical properties are expected to be ameliorated, primarily, as a result of the increase in soil organic matter (cf. Mekuria et al. 2007). The micro-catchments as well as the stone and soil bunds capture water from the surface flow and increase soil water infiltration and the moisture available to the vegetation (Descheemaeker et al. 2006).

By and large, the local people expressed the opinion that the exclosures had increased grass cover, decreased soil erosion, and increased rainfall frequency following the regeneration of vegetation on the degraded lands. They particularly emphasised the benefits gained from reduced soil erosion on the lower slopes of the watersheds. Most of the observations of local people concerning the biophysical changes are in line with the scientific evidence.

Prior to the rehabilitation intervention at AD, the vegetation was very scanty or nearly absent; however, the above-ground biomass (particularly carbon sequestered by trees) and the soil carbon are expected to increase substantially after the intervention. According to Silver et al. (2000), tropical secondary forest succession sequesters a significant amount of carbon over a relatively short period of time. If the area exclosure is maintained for a longer period of time, secondary succession will advance to a mature forest with a closed canopy, which, in turn, will sequester more carbon in both above-ground biomass and in the soil. However, the lack of sufficient amount of propagules of the native woody species and highly degraded soils (by water erosion) may retard or arrest the succession process.

Socio-economic effects of the rehabilitation intervention

The rehabilitation intervention at AD has brought a positive change in the perception of the local people; from a pessimistic position at the beginning of the intervention to a more optimistic position at a later phase of implementation. At the start of the project, 20% of the local people agreed with the establishment of exclosures since degraded lands had no value, 20% agreed to establish exclosures on half of the degraded land and leave the other half for

Figure II 18.4 Exclosure as source of fodder, naturally grown grass (left) and planted elephant grass (right). Grass is harvested via cut-and-carry system for animal fattening scheme at Choroko, Alaba, southern Ethiopia. ©Alaba Agricultural office

free grazing, 20% accepted exclosures due to peer influence or just to respect the decision of local authorities, while the remaining 40% did not accept the idea due to restriction of free grazing in exclosures or fear of unforeseen situations (Office of Agriculture 2008). Later on, 95% of the local communities have developed a positive attitude towards establishment of exclosures after they benefited from collecting thatching grass, fodder for livestock, and construction wood either at low cost or free of charge (Office of Agriculture 2008).

The rehabilitation intervention has also had a positive impact on the livelihoods of local people. Several direct and indirect benefits from the exclosures were mentioned by the local community in AD. First, ESWA members were able to generate considerable income from selling of grass and fattened cattle and deposit savings in the association's bank account (ETB 30 000 or USD 1764). Some of the deposited money was used to buy oxen for fattening and for fodder harvested from the exclosure (Figure II 18.4). Second, the women were also obliged to save Ethiopian Birr (ETB) 20 (USD 1.1) per month from their monthly income earned through the food-for-work program. Third, priority was given to ESWA members to collect construction materials, thatching grass, and grass for livestock – after obtaining permission from the association committee and approval of the PA. But, free grazing was not allowed in order to avoid mortality of naturally regenerating indigenous woody species due to browsing and trampling (Teketay et al. 2010). Fourth, the community benefited from harvesting of planted eucalypt trees, with wood used for construction of schools, a health post and *kebele* (local administrative office). However, the collection of fuelwood has not yet materialised. Other studies in northern Ethiopia showed that farmers also value aesthetic and wildlife revival in exclosures (Birhane 2002).

Sustainability of area exclosures

The success of rehabilitation of degraded lands mainly depends on clear land tenure – well-defined and secure property rights for land and trees (Muys et al. 2006). The form of land-tenure arrangement that better suits a community to manage the exclosures and maintain equitable benefit-sharing among members is not clearly defined in Ethiopia (Nedessa et al. 2005). For example, studies in northern Ethiopia showed that the community strongly favoured private over communal or state ownership and divided the exclosure areas among private individuals. On the other hand, another study in the same region reported that farmers prefer community-(village-) level management system over private ownership (Mengistu et al. 2005a, 2005b). In AD, the preferences of the local people were not clear, but currently, exclosures are managed communally. To overcome problems of tenure insecurity, the AD Land Administration Department, together with the DOA, have already planned to offer a certificate of land-use rights for members of ESWA. Above all, the sense of ownership and equitable benefit sharing are keys to the sustainability of exclosures (Birhane 2002, Mengistu et al. 2005a, 2005b, Birhane et al. 2006).

Some of the factors that enhance sustainable use and conservation of the exclosures in AD include the growing sense of ownership, management by a local association, benefits generated from animal fattening, provisioning of thatch grass, improvements in community infrastructure, women's empowerment, growing tradition of saving money, and increasing respect of local by-laws. In general, the benefits people derive from exclosures are incentives that help to strengthen their support for rehabilitation of degraded forests and woodlands. A community's sense of ownership in AD may increase as it gains authority over direct use, participates in decision-

making, and establishes its own by-laws (Mengistu et al. 2005b). However, there are several factors that may challenge the sustainability of exclosures in AD, such as emergence of wild animal pests (e.g. warthogs and baboons) that destroy agricultural crops, absence of management plans, insecurity of land tenure, increase in youth unemployment and landlessness, inequity in benefit sharing (the bulk of direct benefits go to ESWA members) and encroachment of livestock (Office of Agriculture 2008).

By having the authority to penalise by-law offenders, local institutions, such as *sera* (a traditional institution that organises mutual help against a crisis or for work) in AD, can enforce the by-laws that regulate the use of exclosures. Similarly, in northern Ethiopia, local by-laws, such as *serit*, have been used to regulate and protect exclosures from trespassers (Birhane 2002). However, by-laws can be ineffective when they lack clear guidelines for their monitoring and focus on fining trespassers rather than improving productivity (Birhane et al. 2006). Moreover, there must be an institution that is mandated to enforce rules and regulations and implement by-laws. In AD, the protection of exclosures is mainly conducted by hired guards. Effective protection and sustainability of exclosures requires that the community take over the responsibility, either by sharing the responsibility among members, who take turns in guarding the exclosures, or by hiring guards.

Another important factor that may compromise the sustainability of exclosures is the lack of clear exit strategies for NGOs actively assisting the rehabilitation interventions and the associated risk of an aid-dependency syndrome. Moreover, there is weak linkage and partnership between the governmental institutions and NGOs with respect to information exchange and coordination of activities. Therefore, NGO interventions should provide adequate training for local people to help themselves and promote strong collaboration with governmental institutions and communities.

Precautionary measures are also essential in order to reduce the overdependence of local people on food-for-work programs and to ensure sustainable management of exclosures. This requires building capacity via training on, among other topics, entrepreneur skills of the locals to add value to products from exclosures – while maintaining the viability of biological resources. Moreover, there is also a need to create off-farm income-generation activities, in particular for youths and the landless section of the community to avert the threats of encroachment on exclosures. It is also essential to address cross-cutting issues such as improving health services, family planning, and education to directly or indirectly reduce the pressure on rehabilitated sites.

18.3.2 Management of areas invaded by alien species

Site description

This case study concerns management of the *Prosopis* invasion in the Afar National Regional State (ANRS), which is a large lowland expanse in the northeastern part of Ethiopia located between N 8°51'–14°34' and E 39°47'–42°24'. The altitude ranges from 144 m below sea level to 2870 m above sea level. The area receives 27 to 110 mm average monthly rainfall during the main rainy season in July–August and about 70 mm monthly mean rainfall from February to April. The mean annual temperature varies between 34°C and 40–47°C (National meteorological service agency 2002). The soil is poorly developed and varies, depending on topography and climate, from alluvial fans and salt marshes to valley incisions caused by the Awash River and its tributaries (Mohr 1971). The region is unique in terms of its ecology – as it supports a variety of endemic flora and fauna – and socio-economic and cultural values (Ensermu et al. 1992, Berihun 2001, Hailu et al. 2004). It hosts several wildlife reserves (such as Yangudi-Rasa National Park and Awash National Park) and is a globally recognised site of the cradle of humankind, where the oldest human ancestors were unearthed. The area supports the livelihoods of pastoralists, with a relatively high livestock population, and provides agricultural lands for conventional and mechanised agriculture, salt mining, and ecotourism.

Prosopis, which is native to South America and the Caribbean, is the major alien invasive species in the ANRS. Available evidence suggests that *Prosopis* was introduced to Ethiopia in the late 1970s from India by the Ministry of Agriculture as a promising multipurpose species for use in land rehabilitation programs (Hailu et al. 2004). The species was planted over large areas in southeastern and southern Ethiopia, particularly during the period from 1986 to 1988. However, soon after its introduction, *Prosopis* proliferated and emerged as an aggressive and invasive species. Today, the total area invaded by *Prosopis* is estimated at 700 000 ha in the ANRS alone (Ryan 2011); severe invasions have been observed in Dubti, Mile, Gewane, Buremoditu, and Amibara; moderate invasions in Logya, Hadar, Dulecha, and Awash; and recent invasions in Yallo and Dalifagae Districts (Dubale 2008). Invasion of *Prosopis* is viewed both as a menace and an opportunity in Ethiopia (Yibekale 2012, Zeraye 2008) and elsewhere in the Horn of Africa (Mwangi and Swallow 2005, Laxén 2007). The invasion has resulted in a decline in agricultural and livestock productivity as well as an increase in incidence of health problems for both livestock and humans (Zeraye 2008), exacerbated biodiversity

loss caused by displacement of indigenous flora, loss of habitat for wild fauna, and blockage of water sources and walking trails (Berhanu and Tesfaye 2006, Kebede 2009). On the other hand, the local communities have already started benefitting from the use of *Prosopis* thickets for various purposes (Zareye 2008).

Management interventions

Several attempts to reclaim land invaded by *Prosopis* have been made. The first pilot management interventions were initiated in 2004 by FARM Africa, an international NGO in collaboration with the local communities and ANRS. The salient features of the restoration interventions were 1) establishment of cooperatives to clear invaded areas and their conversion into crop and pasturelands; 2) processing of *Prosopis* pods and seeds for livestock feed, thereby reducing the propagule load and its subsequent regeneration; 3) introduction of efficient production and processing techniques and access to sustainable markets for charcoal and fuelwood obtained from *Prosopis*; and 4) community mobilisation to uproot seedlings emerging in newly invaded areas (Getachew 2008). To test the pilot management interventions, four cooperatives, made up of 179 members, were established in Amibara (Serkamo and Sedhafagae) and Gewane (Gelaladura and Beida) Districts that have experienced severe invasion.

In the case study area, the main actors are ANRS, the local administration bodies, traditional community leaders, cooperatives, and technical support groups (NGOs). ANRS controls all decision-making power concerning the management of the *Prosopis* invasion, including licensing of cooperatives, regulation of cooperatives' activities, and taxation. All cooperatives have their own by-laws, which outline their activities, including cutting trees at least 10 cm belowground (Hailu et al. 2004), controlling coppicing, marking the boundaries of the operational areas of each cooperative, protecting indigenous tree species, prioritising pasturelands and croplands for clearing, and restoring cleared land.

Biophysical changes after rehabilitation interventions

Prosopis thickets create an oasis within the arid environment through amelioration of the microclimate, improving soil fertility through nitrogen fixation, combating desertification, and restoring denuded and salinity-affected areas (Wakie et al. 2012). But its rampant spread warrants control measures. The management intervention has brought considerable change in the landscape and the semi-arid ecosystem functions. The four cooperatives managed to clear 406 ha of invaded land and convert it into other land-use types. In these areas, cooperatives cleared *Prosopis* and cultivated forage, food crops, and cash crops. Additional benefits from the rehabilitation interventions include reduced chance of secondary invasion of lands cleared and cultivated; reduction in illegal charcoal production, since people involved in illegal charcoal making work under the cooperatives' supervision; and recovery of indigenous trees, shrubs, and grasses in *Prosopis*-cleared lands.

Socio-economic effects of the interventions

The management interventions have also brought considerable livelihood benefits (Dubale 2006). For instance, the four cooperatives managed to clear 406 ha of invaded land and generated a net profit of USD 300 075 from the sale of 195 949 sacks of charcoal within a year. The intervention had also created 233 509 man-days per year of labour opportunities for daily labourers, equivalent to USD 218 221 of income. Similarly, cooperatives involved in processing and marketing of *Prosopis* pods and seeds generated considerable income. For instance, the Sedhafagae Cooperative alone generated a net profit of USD 5850 from processing and marketing crushed pods and seeds as supplementary animal feed in 2007 (Getachew 2008). In areas where Pastoral Livelihood Initiative (PLI) projects have been launched, cooperatives generated income amounting to USD 675 to USD 1270 from the sale of vegetables and sesame grown on reclaimed land in one cropping season. There is good market opportunity for cooperatives involved in processing of animal feed and producing charcoal from *Prosopis*. The cooperatives are linked to animal-feed processing factories as major market outlets for crushed and milled pods and seeds. Local markets have also emerged where cooperatives buy pods from local people, process them, and sell them back to local livestock keepers. One of the active cooperatives engaged in pod crushing (Sedhafagae) processed and sold 10 000 kg of pods to local and government institutes (Getachew 2008). Similarly, cooperatives engaged in charcoal production are linked with wholesalers in major cities along the Addis Ababa-Djibouti highway. Generally, the favourable market opportunities are an incentive for popular participation in managing the *Prosopis* invasion since financial incentives are a key factor for the success of proactive restoration measures.

Sustainability of managing alien species invasion

Although the pilot interventions to manage the invasion of alien species provide empirical evidence about the importance of managing *Prosopis* invasion through its use (Hailu et al. 2004) to improve the livelihoods of the Afar pastoral community and recover indigenous species, the approach is not free from limitations (Dubale 2006, Getachew 2008). Some of the major limitations include the failure to abide by the by-laws and the inability to enforce them; lack of communication and coordination among different government bodies (e.g. forest guards) and traditional leaders, as well as among cooperatives engaged in charcoal marketing; low level of participation of cooperative members in decision-making; lack of transparency in the marketing and accounting systems; and the propensity of the regional government, through its Pastoral, Agricultural, and Rural Development Bureau, to control the activities of the cooperatives.

Despite the lack of clear policies for managing invasive alien species, positive developments have been observed both in research and restoration interventions. On the research front, biological properties that promote the species invasiveness and control measures and its ecological and socioeconomic impacts (both positive and negative) have been documented (Hailu et al. 2004, Berhanu and Tesfaye 2006, Zeraye 2008). The policy barrier for the management of the *Prosopis* invasion can be addressed through decentralised management. Decentralisation, a process through which powers, responsibilities, and resources are 'transferred by the central state to lower territorial entities and locally elected bodies, enhances use and management efficiency and equity and reduces conflicts over natural resources (Ribot 2009). It also contributes to poverty reduction through improving access to forest products for consumption and trading (Cavendish 2000, Larson 2005) and fosters good governance at the local level (Ribot 2004).

The challenges for decentralisation of the management of the *Prosopis* invasion in Afar region are analysed below in terms of resource sharing, empowerment, transparency, and accountability, which are the main tenets of decentralisation. Here, decentralisation of management is conceived as the transfer of authority and management functions related to the existing *Prosopis* stands from ANRS (the highest administrative body) to local pastoral communities. The first step in any decentralisation process is sufficient knowledge of the resource base, since the key aim of decentralisation is to transfer resources to the local administrative entities. Setting clear boundaries in common-pool resource management schemes is also essential to minimise conflicts over limited resources (Wily 2002). The case study in ANRS clearly shows lack of clear demarcation of the operational areas of the different cooperatives, and some cooperatives even moved outside their districts, thus, creating conflicts between cooperatives and residents. Furthermore, a realistic land-use plan detailing areas to be cleared off *Prosopis* invasion and subsequent management of cleared lands is lacking. Lack of clearly defined land-tenure rights also adds complexity into the transfer of resources, particularly the management of lands reclaimed from *Prosopis* invasion.

To meaningfully transfer power, first the power relation between the different actors should be mapped out and their responsibilities defined. In the case study area, ANRS retained all decision-making power over *Prosopis* management. The decision of ANRS to ban all cooperatives and individuals from producing and marketing charcoal is a particular example of the disenfranchisement of the poor rural populations from benefitting from the use of *Prosopis* stands to support their livelihoods, on one hand, and the efforts to control the spread of the *Prosopis* invasion on the other. The cooperatives simply attend meetings and assist in decision-making without influencing the decisions – the so-called passive participation. The technical support groups have provided sufficient technical support and creation of awareness. Another important aspect of decentralisation is the level to which power and responsibility for resources are transferred. In principle, the cooperatives are the ones to whom the real decision-making power should be given. But, in reality, some degree of power over the management of the *Prosopis* invasion has been passed only to district and local administration entities, reflecting the reluctance of ANRS to transfer significant jurisdiction to cooperatives over resources. Another striking feature of the piloted cooperatives is the disenfranchisement of women from participating in charcoal production and marketing as well as their involvement in decision-making, as virtually very few women are included in the management committee.

Transparency and accountability are key elements in the decentralisation process, as communication has a positive impact on establishing trust and mutual agreement on rules regarding the management and use of a resource (Walker and Ostrom 2007). Lack of transparency with the case-study cooperatives has resulted in a low level of participation of cooperative members in decision-making and mistrust between management committees and members since major decisions are made by few management elites. These are commonplace and serious problems in many common-pool resource management schemes (e.g. Coulibaly-Lingani et al. 2011). There is also evidence of poor accountability within the case-study cooperatives, the lack of a proper accounting and auditing system, which is further complicated

by the involvement of some local leaders in charcoal marketing. Thus, nepotism is a major concern and has an adverse effect on the decentraliaation of management, as also reported elsewhere (Tacconi 2007, Coulibaly-Lingani et al. 2011). It is generally believed that institutions that fail to reflect local accountability systems in resource management fail to achieve successful socio-economic and ecological outcomes of common property resource management (Brown and Lassoie 2010).

18.4 Conclusions and recommendations

18.4.1 Area exclosures

The forest rehabilitation activities in Alaba District are implemented at a site level. These rehabilitation sites are integral parts of the existing land-use mosaic within the landscape, and the different land uses have biophysical and socioeconomic linkages. The on-site activities have an off-site impact: a case in point is the connection between the upper and lower catchments, such as in the Bilate watershed. Hence, landscape-level planning is recommended for the rehabilitation of degraded forestlands, where the multiple functions of the different land uses are taken into account. Furthermore, it is easier to make the trade-off between rehabilitation (such as area exclosures) and livelihoods requirements at a landscape-level than at the site-level (Lamb et al. 2005).

The establishment of ecological corridors will facilitate the movement of organisms (gene flow) and increase the viability and persistence of isolated populations. Furthermore, corridors may enable the re-colonisation of a site that has suffered local extinctions (Hess and Fischer 2001). Corridors are also important for wildlife, allowing periodic movements among different habitat types used for different purposes. The establishment of corridors, particularly, based on existing natural corridors, such as riparian forests, should be considered when designing and implementing forest rehabilitation projects in Ethiopia. Riparian corridors are cheaper to establish and can connect highland and lowland habitats, thereby facilitating migration across different elevations (Douglas 1997). Whenever possible, considerations need to be given to the establishment of corridors that connect forest rehabilitation sites with remnant natural forest patches, including sacred groves.

In AD, some of the planted exotic woody species, such as *A. saligna*, may turn out to be invasive and thus monitoring of their spread is required. In general, native fast-growing and sturdy early-successional woody species should be considered first before resorting to planting non-native species. In addition, there is a need to broaden the pool of potential woody and herbaceous species (particularly native species) that are suitable for rehabilitating degraded lands and forests in Ethiopia. Although there is an increase in the diversity of flora and fauna in the rehabilitated areas, expediting the secondary succession process through enrichment planting of rare and endangered species is recommended, particularly late-successional species. Also, enrichment planting using nitrogen-fixing fodder trees and shrubs will contribute to the amelioration of soil fertility and cater to the pressing need for cattle fodder. Enrichment planting of woody species with fleshy fruits is also desirable to attract seed dispersers and enhance the seed rain at the rehabilitation site. The soil seed bank in Ethiopia is generally poor (Teketay 1996, Lemenih and Teketay 2004) once the standing vegetation is cleared, thus it plays little role in the natural regeneration of woody species.

Experiences in AD and other parts of Ethiopia have shown that in the beginning people are sceptical about the effectiveness of area exclosures as a rehabilitation intervention, benefits sharing, and use rights regarding exclosures (Birhane 2002, Birhane et al. 2004, 2006, Mengistu et al. 2005b, Nedessa et al. 2005, Office of Agriculture 2008). But the interventions have led to more positive perceptions about rehabilitation. However, several policy, administrative, and organisational hurdles and shortcomings severely hamper the realisation of the full potential of rehabilitation initiatives in restoring ecosystems and improving livelihoods. These include the lack of clear guidelines regarding the goals of rehabilitation, management plans, and indicators against which rehabilitation success will be evaluated.

Area exclosures can be viable systems if they have clearly defined users, clearly defined resource boundaries, and realistic, locally established rules (Mengistu et al. 2005b). Most often, attention of the DOA and other stakeholders has been focused on biophysical impacts of rehabilitation of degraded lands, while economic and social well-being of the households have often been neglected (Lovejoy 1985). For example, one of the major challenges with exclosures is the restriction of free livestock grazing, and hence there has to be a strategy for compensating people for the loss of access to grazing areas. To reduce local conflicts, the demand for free grazing land should also be considered when planning establishment and expansion of exclosures (Mekuria et al. 2007). In addition to the cut-and-carry (of grass) method, depending on the management plan and carrying capacity, some form of selective grazing should be practiced inside exclosures to avoid potential conflict among local people, while an intermediate level of disturbance (by grazing) may enhance floristic diversity (Nedessa et al. 2005).

The dependency of local people for grazing and

fuelwood can be reduced through introduction of agroforestry practices, energy-efficient stoves, and woodlots at the farm level. Agricultural productivity should also be enhanced to create better income and food self-sufficiency, consequently reducing pressure on the exclosures. Fodder species ought to be integrated within agroforestry practices, woodlots, and exclosures in order to cater to the pressing need of animal feed. Generally, rehabilitation of degraded forests may also contribute directly to the alleviation of poverty by generating cash income and indirectly by improving crop and animal productivity (Gebre Egziabher 2006).

Furthermore, little emphasis has been paid to community participation in management and decision-making. Such a failing can contribute to the community's sense of alienation and indifference and ultimately to the failure of rehabilitation endeavours. Therefore, understanding the social and economic system of the local people is the starting point for successful rehabilitation. Equitable benefit sharing and genuine participation of local people at all levels (decision-making as well as design, management, and evaluation of exclosures) are foundations for sustaining exclosures.

Involving women in the day-to day running of restoration activities and benefit sharing from the exclosure at Alaba is a breakthrough in the struggle to overcome gender bias in a society where men have had the sole decision-making power in the household. Women also benefit from the exclosures through access to grass and firewood. Rehabilitation may revive springs and make it easier for women to fetch water.

In spite of multiple benefits of exclosures, local people in AD have strongly complained after the establishment of exclosures about the emergence of some wild animals, such as warthogs and baboons, which are browsing and damaging agricultural crops around the exclosures. There must be coordinated efforts among concerned offices (e.g. DOA) and administrative bodies to overcome the problem by using local knowledge and assistance of experts from the Wildlife Conservation Authority.

18.4.2 Alien species invasion management

Prosopis invasion in ANRS is a serious concern due to the extent of invasion, impacts on dryland ecosystems, ecology, and socio-economic effects on the pastoral communities. The management of *Prosopis*-invaded areas has been a daunting task as a result of diverging views on the management strategies, ranging from complete eradication to management through utilisation. The pilot management interventions have clearly demonstrated that, if properly managed, the *Prosopis* thickets are valuable resources for diversifying rural livelihoods vulnerable to food insecurity and for protecting the functionality of the semi-arid ecosystem. However, the lack of a clear policy direction and institutional mandate, coupled with technical and financial difficulties, have constrained the successful management of the *Prosopis* invasion in ANRS. Decentralisation of management of the *Prosopis* invasion could be a promising means of institutionalising and scaling up of popular participation. To address the challenges for decentralisation of management of *Prosopis* invasion, the following recommendations are suggested.

1. The removal of *Prosopis*, followed by conversion of restored lands into other land-use forms (active restoration), is more effective in controlling secondary invasions than passive restoration (simply clearing the invaded area). If passive restoration is pursued, an incentive mechanism should be established (e.g. remuneration) for people participating in these activities.
2. The operational management units of each cooperative should be clearly demarcated within each district and a detailed land-use plan prepared. Arrangements for secured land-tenure rights should be made for restored areas.
3. Identifying the various actors and defining their roles and responsibilities must be worked out in order to establish a revamped local structure, including elected local leaders, traditional community leaders, and representatives of the cooperatives. Any such new institution should regularly hold general public meetings to prepare annual plans of activities, make decisions regarding the allocation of revenues, and present annual audit reports.
4. ANRS should minimise its influence to leave more space for decision-making by members of the cooperatives.
5. To address transparency and accountability issues, mechanisms to enhance information flows, collectively agreed guidelines for benefit-sharing and robust auditing, and audit reporting systems should be established at the local level. In this regard, both government and NGOs would assist through training of cooperative members in bookkeeping. Members of the management committee should be democratically elected and positive affirmative action should be considered to increase the participation of women in the leadership.
   To deter illegal activities, effective law-enforcement mechanisms should be put in place.

References

Aerts, R., Nyssen, J. & Haile, M. 2009. On the difference between ''exclosures'' and ''enclosures'' in ecology and the environment. Journal of Arid Environments 73: 762–763.

Alaba MoRAD 2012. Alaba Office of Agriculture. Alaba, Ethiopia.

Anagae, A., Reda, F., Tesfaye, G., Admasu, A. & Ayalew, Y. 2004. Policy and stakeholder analysis for invasive plants management in Ethiopia. EAR Organization, Ethiopia, 60 p.

Bekele, M. 2008. Ethiopia's environmental policies, strategies and programs. In: Taye, A. (ed.). Digest of Ethiopia's national policies, strategies and programs. FSS, Addis Ababa, Ethiopia. p. 337–69.

Berhanu, A. & Tesfaye, G. 2006. The prosopis dilemma, impacts on dryland biodiversity and some controlling methods. Journal of the drylands 1(2): 158–164.

Berihun, G-M. 2001. Population status and some ecological aspects of soemmering's gazelle (gazella soemmerringii) in Awash national park and Allidegi wildlife reserve, Ethiopia. M.Sc. thesis. Addis Ababa University, Ethiopia.

Birhane, E. 2002. Actual and potential contribution of enclosure to enhace biodiversity in dry lands of Eastern Tigray with particular emphasis on woody plants. M.Sc. thesis report no. 70. Swedish University of Agricultural Sciences. Skinnskatteberg, Sweden.

Birhane, E., Teketay, D. & Barklund, P. 2004. Enclosures as a tool for rehabilitating degraded woodlands of Ethiopia. In: Blay, D., Bonkoungou, E., Chamshama, S.A.O. & Chikamai, B. Rehabilitation of degraded lands in Sub-Saharan Africa. FORNESSA and IUFRO-SPDC, Neulengbach, Austria, p.73–77.

Birhane, E., Teketay, D. & Barklund, P. 2006. Actual and potential contribution of exclosures to enhance biodiversity of woody species in the drylands of Eastern Tigray. Journal of the Drylands 1(2): 134–147.

Bongers, F. & Tennigkeit, T. 2010. Degraded forests in Eastern Africa: Introduction. In: Bongers, F. & Tennigkeit, T. (eds). Degraded forests in Eastern Africa: Management and restoration. Earthscan Ltd., London, UK. p. 1–18.

Brown, H.C.P. & Lassoie, J.P. 2010. Institutional choice and local legitimacy in community-based forest management: lessons from Cameroon. Environmental Conservation 37(03): 261-269.

Brown, S., Ambagis S., Grais A. & Pearson, T. 2010. Regional analysis of GHGs from agriculture in countries of East and West Africa: Progress report. Report to ILRI and ICRISAT.

Cavendish, W. 2000. Empirical regularities in the poverty-environment relationship of rural households: Evidence from Zimbabwe. World Development 28(11): 1979–2003.

Coulibaly-Lingani, P., Savadogo, P., Tigabu, M. & Oden, P.C. 2011. Decentralization and community forest management in Burkina Faso: Constraints and challenges. International Forestry Review 13(4): 476–486.

Dale, V.H., Joyce, L.A., Mcnulty, S., Neilsonr, P., Ayres, M.P., Flannigan, M.D. Hanson, P.J., Irland, L.C., Lugo, A.E., Peterson, C.J., Simberloff, D., Swanson, F.J., Stocks, B.J. & Wotton, B.M. 2001. Climate change and forest disturbances. BioScince 51(9): 723–734.

Darbyshire, I., Lamb, H. & Umer, M. 2003. Forest clearance and regrowth in Northern Ethiopia during the last 3000 years. The Holocene 13(4): 537–546.

Descheemaeker, K., Nyssen, J., Poesen J., Haile, M., Muys, B., Raes, D., Moeyersons, J. & Deckers, J. 2006. Soil and water conservation through forest restoration in exclosures of the Tigray highlands. Journal of the Drylands 1(2): 118–133.

Dessie, G. 2007. Forest decline in South Central Ethiopia: Extent, history and process. Ph.D. dissertation. Department of Physical Geography and Quaternary Geology. Stockholm University, Stockholm, Sweden.

Douglas, J.W.O. 1997. Conservation reserves in heterogeneous landscapes. In: Meffe, G.K. & Carrol, C.R. (eds.). Principles of conservation biology. Sinauer Associates, Inc. 729 p.

Dubale, A. 2006. Impacts of prosopis juliflora invasion and control using charcoal production in Afar national regional state, Ethiopia. M.Sc. thesis. University of Wales, Bangor, UK.

Dubale, A. 2008. Invasive plants and food security: the case of prosopis juliflora in the Afar region of Ethiopia. IUCN. 13 p.

EDRI 2010. Preliminary assessment by the EDRI of impacts, cost and feasibility of strategy options–Climate Resilient Green Growth initiative.

Ensermu, K., Sebsebe, D., Zerihun, W. & Edwards, S. 1992. Some threatened endemic plants of Ethiopia. In: Edwards S. & Zemede A. (eds.). The status of some plant resources in parts of tropical Africa. Botany 2000: East and Central Africa. NAPRECA, Addis Ababa University, Addis Ababa, Ethiopia. p. 35–55.

Eshetu, Z. 2000. Forest soils of Ethiopian highlands: Their characteristics in relation to site history: Studies based on stable isotopes. Ph.D. thesis, Acta Universitatis Agriculturae Sueciae, Silvestria 147, Umeå, Sweden. 80 p.

FAO 2010. Global forest resources assessment 2010: Main report. FAO Forestry Paper No. 163. FAO, Rome, Italy. 340 p.

Federal Democratic Republic of Ethiopia 2010. Forest carbon partnership facility (FCPF), readiness preparation proposal (R-PP). Country Submitting the Proposal: Federal Democratic Republic of Ethiopia. Date re-submitted (formal): 25 May 2011. 229 p.

Friis, I., Demissew, S. & Breugel, P.V. 2010. Atlas of potential vegetation of Ethiopia. The Royal Danish Academy of Sciences and Letters. Biologiske Skrifter 58. 307 p.

Gebre-Egziabher, T.B. 2006. The role of forest rehabilitation for poverty alleviation in drylands. Journal of the Drylands 1(1): 3–7.

Getachew, G. 2008. Experiences on prosopis management: Case of Afar region. FARM-Africa.

Gobena, M. 2010. Effects of large-scale land acquisition in rural Ethiopia: The case of Bako-Tibe Woreda. M.Sc. thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden. 52 p.

Hailu, S., Teketay, D., Nemomissa, S. & Assefa, F. 2004. Some biological characteristics that foster the invasion of prosopis juliflora (Sw.) DC at middle Awash Rift Valley area, Northeastern Ethiopia. Journal of Arid Environments 58: 134–153.

Hess, G.R. & Fischer, R.A. 2001. Communicating clearly about conservation corridors. Landscape and Urban Planning 55: 195–208.

IPMS 2005. Alaba pilot learning site diagnosis and program design. 92 p.

IPMS 2007 [Internet site]. IPMS Atlas 2007. Available at: http://www.ipms-ethiopia.org/content/files/Documents/Atlas/Alaba-atlas2007.pdf [Cited 10 Jan 2013].

Jagger P., Pender, J. & Gebremedhin, B. 2005. Trading Off Environmental Sustainability for Empowerment and Income: Woodlot Devolution in Northern Ethiopia. World Development 33: 1491–1510.

Kebede, A. 2009. Sustaining the Allideghi grassland of Ethiopia: Influence of pastoralism and vegetation change. Utah State University, Logan, Utah, USA. 296 p.

Lamb, D., Erskine, P.D. & Parotta, J.A. 2005. Restoration of degraded tropical forest landscapes. Science 310: 1628–1632.

Larson, A.M. 2005. Democratic decentralization in the forestry sector: lessons learned from Africa, Asia and Latin America. In: Colfer, Carol J.P. & Capistrano, D. (eds.). The politics of decentralization – Forests, people and power. Earthscan, London. p. 32–62.

Lavers, T. 2012. 'Land grab' as development strategy? The political economy of agricultural investment in Ethiopia. Journal of Peasant Studies 39(1): 105–132.

Laxén, J. 2007. Is prosopis a curse or a blessing? – An ecological-

economic analysis of an invasive alien tree species in Sudan. Ph.D. Dissertation. University of Helsinki, Helsinki, Finland. 199 p.

Lemenih, M. 2010. Growing eucalypts by smallholder farmers in Ethiopia. In: Gil, L., Tadesse, W., Tolosana, E. & Lopez, R. (eds.). Proceedings of the conference on eucalyptus species management, history, status and trends in Ethiopia 15–17 Sep 2010. EIAR, Addis Ababa, Ethiopia. p. 91–103.

Lemenih, M. & Teketay, D. 2004. Restoration of native forest flora in the degraded highlands of Ethiopia: Constraints and opportunities. SINET: Ethiopian Journal of Science 27(1): 75–90.

Lemenih, M., Tolera, M. & Karltun, E. 2008. Deforestation: Impact on soil quality, biodiversity and livelihoods in the highlands of Ethiopia. In: Sanchez, I.B. & Alonso, C.L. (eds.). Deforestation research progress. Nova Science Publishers, New York, USA. p. 21–39.

Lovejoy, T.E. 1985. Rehabilitation of degraded tropical forest lands. Commission on Ecology Occasional Paper No. 5. IUCN, Gland, Switzerland.

McNeely, J.A. 2004. Strangers in Our Midst: The Problem of Invasive Alien Species. Environment (6): 16–31

Mekuria, W., Veldkamp, E., Haile, M., Nyssen, J., Muys, B. & Gebrehiwot, K. 2007. Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. Journal of Arid Environments 69(2): 270–284.

Mengistu, T., Teketay, D., Hulten, H. & Yemshaw, Y. 2005a. 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.

Mengistu, T., Teketay, D., Hulten, H. & Yemshaw, Y. 2005b. The role of communities in closed area management in Ethiopia. Mountain Research and Development 25(1): 44–50.

MOFED 2010. Growth and Transformation plan 2010/11-2-14/15, Vol. I. main text. Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

Mohr, P.A. 1971. The geology of Ethiopia. University College of Addis Ababa, Addis Ababa, Ethiopia. 268 p.

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.

Mwangi, E. & Swallow, B. 2005. Invasion of prosopis juliflora and local livelihoods: Case study from the lake Baringo area of Kenya. ICRAF working paper no. 3. World Agroforestry Center, Nairobi, Kenya. 66 p.

National meteorological service agency 2002. Ten years mimeographed weather report. Addis Ababa, Ethiopia.

Nedessa, B., Ali, J. & Nyborg, I. 2005. Exploring ecological and socio-economic issues for the improvement of area enclosure management: A case study from Ethiopia. DCG Report No. 38. DCG, Oslo, Norway. 55 p.

Nyssen, J., Haile, M., Naudts, J., Munro, N., Poesen, J., Moeyersons, J., Frankl, A., Deckers, J. & Pankhurst, R. 2009. Desertification? North Ethiopia re-photographed after 140 years. Science of the Total Environment 407: 2749–2755.

Nyssen, J., Poesen, J., Moeyersons, J., Deckers, J., Haile, M. & Lang, A. 2004. Human impact on the environment in the Ethiopian and Eritrean highlands - a state of the art. Earth-Science Reviews 64: 273–320.

Office of Agriculture 2008. The perception of local communities towards area exclosures: A case study at Alaba woreda, Southern Ethiopia.

Rahmato, D. 2004. Land policy in Ethiopia at the crossroads. In: Rahmato, D. (ed.). Land Tenure and Land Policy In Ethiopia after the Derg. Proceedings of the Second Workshop of the Land Tenure System. Working Paper on Ethiopian Development. IDR. AAU. No. 8.

Reusing, M. 1998. Monitoring of natural high forests in Ethiopia. GTZ, Addis Ababa, Ethiopia.

Ribot, J.C. 2004. Waiting for democracy: The politics of choice in natural resource decentralization. WRI, Washington, DC., USA. 140 p.

Ribot, J.C. 2009. Forestry and democratic decentralization in Sub-Saharan Africa: A rough review. In: German, L., Karsenty, A. & Tiani, A.M. (eds.). Governing Africa's forests in a globalized world. Earthscan, London, UK. p. 29–55.

Ritler, A. 1997. Land use, forests and the landscape of Ethiopia 1699–1865: An inquiry into the historical geography of Central/Northern Ethiopia. Research Report 38. Soil conservation research Project, University of Bern and CDE, Bern, Switzerland.

Ryan, F. 2011. US forest service technical assistance trip to Ethiopia: Invasive species management. USAID, 26 p.

Silver, W.L., Ostertag, R. & Lugo, A.E. 2000. The potential for carbon sequestration through reforestation of abandoned tropical agricultural and pasture lands. Restoration Ecology 8(4): 394–407.

Stebek, N.E. 2011. Between 'land grabs' and agricultural investment: Land rent contracts with foreign investors and Ethiopia's normative setting in focus. Mizan Law Review 5(2): 175–214.

Tacconi, L. 2007. Decentralization, forests and livelihoods: Theory and narrative. Global environmental change 17(3–4): 338–348.

Tadesse, D. 2007. Forest cover change and socioeconomic drivers in Southwest Ethiopia. M.Sc. thesis. Centre of Land Management and Land Tenure, Technische Universität München, Munich, Germany.

Tegegn, G.G. 2008. Experiences on Prosopis Management: Case of Afar Region. Farm Africa, Ethiopia. 35 p.

Teketay, D. 1996. Seed ecology and regeneration in dry afromontane forests of Ethiopia. Acta Universitatis Agriculturae Sueciae, Silvestria 4. Umeå, Sweden.

Teketay, D., Lemenih, M., Bekele, T., Yemshaw, Y., Feleke, S., Tadesse, W., Moges, Y., Hunde, T. & Nigussie, D. 2010. Forest resources and challenges of sustainable forest management and conservation in Ethiopia. In: Bongers, F. & Tennigkeit, T. (eds.). Degraded forests in Eastern Africa: Management and restoration. Earthscan Ltd., London, UK. p. 19–63

Tigabu, M. & Teketay, D. 1998. Formulation of Afar regional state forestry action program, Ethiopia: Ecosystem and biodiversity conservation component. Addis Ababa, Ethiopia.

Wakie, T., Evangelista, P. & Laituri, M. 2012. Utilization assessment of prosopis juliflora in Afar region, Ethiopia. US Forest Service, USDA office of international programs and USAID PLI II project.

Walker, J. & Ostrom, E. 2007. Trust and reciprocity as foundation for cooperation: Individuals, institutions and context. Working paper. Indiana University, Bloomington, Indiana, USA. 43 p.

WBISP 2004. Forest resources of Ethiopia. Ministry of Agriculture. Addis Ababa, Ethiopia.

Wily, L.A. 2002. Participatory forest management in Africa: An overview of progress and issues. Presentation in the Second international workshop on participatory forestry in Africa. Defining the way forward: sustainable livelihoods and sustainable forest management through participatory forestry. 18-22 February 2002. Arusha, United Republic of Tanzania.

Yibekale, Y. 2012. Ecological and economic dimensions of the paradoxical invasive species- prosopis juliflora and policy challenges in Ethiopia. Journal of economics and sustainable development 3(8): 62–70.

Yirdaw, E. 1996. Deforestation and forest plantations in Ethiopia. In: Palo, M. & Mery, G. (eds.). Sustainable forestry challenges for developing countries. Kluwer Academic Publishers, The Netherlands. p. 327–342.

Zeraye, M. 2008. Invasion of prosopis juliflora (SW.) DC and rural livelihoods: The case of afar pastoralists at middle Awash area of Ethiopia. M.Sc. thesis. Department of International Environmental and Development Studies, Norwegian University of Life Sciences, Norway. 58 p.