Exclosures as forest and landscape restoration tools: lessons from Tigray Region, Ethiopia

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SUMMARY

In response to the 2011 Bonn Challenge, Ethiopia has committed to restoring 15 million ha of degraded forest and savannah. This study focuses on rehabilitation of communal lands in Tigray through the use of exclosures. Exclosures, often established by using so-called social fences in Ethiopia, are widely recognized as effective in restoring vegetation. This study identified factors contributing to the success of exclosures. After selecting nine successful exclosures from three agro-ecological zones, data were collected through a formal survey of 324 randomly selected households, and from focus group discussions and key informant interviews. Local communities recognize the role of exclosures in increasing site productivity and vegetation cover. However, this positive attitude is often challenged by shortages of livestock feed as a competing priority. Results of our analysis are presented here, bringing insights on factors affecting successful planning and implementation of exclosures and their wider adoption as a means of landscape rehabilitation.

Keywords: communal lands, rehabilitation, livestock, scaling-up, vegetation

Exclos comme instruments de restauration de la forêt et du paysage: leçons provenant de la région Tigray, en Ethiopie

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Répondant au défi de Bonn en 2011, l'Ethiopie a décidé de restaurer 15 millions d'ha de forêt et de savane dégradées. Cette étude se concentre sur la réhabilitation des terrains communaux au Tigray, par l'utilisation d'exclos. Les exclos, souvent établis en utilisant des barrières soi-disant sociales en Ethiopie, sont généralement considérés efficaces dans la restauration de la végétation. Cette étude identifie les facteurs contribuant au succès des exclos. Après avoir sélectionnés neufs exclos réussis, provenant de trois zones agro-écologiques, les données furent recueillies à l'aide d'une étude formelle de 324 foyers pris au hasard, ainsi que de discussions de groupes de focus et d'interviews d'informateurs-clés. Les communautés locales reconnaissent le rôle des exclos dans l'augmentation de la productivité du site et du couvert végétal. Cette attitude positive est cependant souvent menacée par une carence de fourrage pour le bétail, une priorité concurrente. Les résultats de notre analyse sont présentés ici, offrant des lumières sur les facteurs affectant la planification efficace et l'application des exclos, ainsi que sur leur application plus large en tant qu'outil de réhabilitation du paysage.

Los recintos como herramientas para la restauración de bosques y paisajes: lecciones de la región de Tigray de Etiopía

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En respuesta al Desafío de Bonn de 2011, Etiopía se ha comprometido a restaurar 15 millones de hectáreas de bosques y sabanas degradadas. Este estudio se centra en la rehabilitación de tierras comunales en Tigray mediante el uso de recintos. Los recintos, a menudo establecidos mediante lo que se denomina como cercas sociales en Etiopía, están reconocidos ampliamente como medidas eficaces para restablecer la vegetación. Este estudio identificó una serie de factores que contribuyen al éxito de los recintos. Una vez que se seleccionaron nueve recintos exitosos en tres zonas agroecológicas, se recolectaron datos mediante una encuesta formal a 324 hogares seleccionados al azar, y por medio de discusiones de grupos focales y entrevistas con informantes clave. Las comunidades locales reconocen el papel de los recintos en el aumento de la productividad de un sitio y de la cobertura de la vegetación. Sin embargo, esta actitud positiva es puesta en tela de juicio a menudo debido a que la escasez de alimento para el ganado se ve como una prioridad que compite con los recintos. Se presentan los resultados del análisis, que aporta perspectivas sobre los factores que afectan la planificación y la implementación exitosas de los recintos y su adopción generalizada como medio de rehabilitación del paisaje.

BACKGROUND

Ethiopia, and particularly the Tigray region, has been facing continuous deforestation and consequent land degradation due to mainly agricultural expansion, overgrazing and unsustainable extraction of wood products (Bishaw 2001). In an attempt to reverse this trend, many efforts have been made in the region since the 1970s (Pohjonen and Pukkala 1990, Tekle 2001). The rehabilitation of degraded lands through establishing exclosures was among such efforts (Birhane 2002, Mekuria *et al*. 2011, Mengistu *et al*. 2005). Exclosures are areas protected from human and animal interference by a physical boundary or a social fence (meaning communal restriction to access) to promote natural regeneration of plants and thus reduce further degradation of formerly degraded lands.

According to Aerts *et al*. (2009), Seyoum *et al*. (2015) and Mekuria *et al.* (2017), exclosures are areas that are closed-off or otherwise protected from human and domestic animal disturbances to allow regenerating native vegetation to regenerate and to reduce further land degradation of the formerly degraded communal grazing lands. Hence, rehabilitation of degraded communal grazing lands through establishing exclosures has become increasingly important in the Tigray region of northern Ethiopia. Similarly, Yayneshet *et al*. (2009) reported that exclosures can be effective in enhancing the composition, diversity and density of vegetation on degraded grazing lands. Moreover, exclosures can be effective in restoring degraded soils and increasing soil carbon in the highlands of Tigray (Mekuria *et al*. 2011). An exclosure allows degraded lands to rest for a number of years and this encourages the regeneration of natural vegetation (Bendz 1986). Exclosures have previously been used to restore communal grazing lands, mainly located on steep slopes. Rehabilitation of degraded lands has been practised in some form in most rural societies around the world. Rotational grazing and deferred pasturing, which allow vegetation to regenerate during the rainy season, have been common practice in Tunisia, Algeria, Niger, Somalia and Ethiopia for many centuries (Birhane 2002, FAO 1979). The selective protection of forest cover is also commonly practised for various reasons. In Ethiopia, for example, restricting the use of forests around churches is an old practice (Birhane 2002, Mengistu *etal*. 2005). Exclosures have also been used to enforce fallow periods to allow the soils of crop or grazing lands to recover, thereby maintaining productivity.

In the mid-1980s, government institutions in Tigray began promoting exclosures as a means of rehabilitating and managing degraded land, and the practice became an integral part of soil and water conservation work (Birhane *et al*. 2006). Since then, this practice has become a common vegetation restoration tool in most of the highlands of the region (Mekuria *et al*. 2011). One of the main reasons why this restoration measure is so popular is that it is a relatively fast way to restore vegetation compared to conventional reforestation. Indigenous or adapted species of grasses, weeds, shrubs and trees are already present, suppressed or dormant in the form of roots or seeds. Existing vegetative material may invade the site faster and with better coverage than planted seedlings, which are often exotic or less well adapted to site conditions (Bendz 1986). The second main reason is that establishment of exclosures is relatively easy and inexpensive, requiring less investment in planting material, site preparation and management compared with plantation establishment. Establishing plantations using introduced seedlings in similar sites costs about 1500 birr [ca. USD 68] per hectare (BoARD 2014). In Ethiopia, the basic costs related to establishing and maintaining exclosures, other than the opportunity cost of setting land aside, are payments to guards employed to prevent incursion by people or livestock.

By 2012, the area under exclosures in the Tigray Region was estimated to be about 1.2 million ha (BoARD 2013) and recently reached 1.5 million ha (Seyoum *et al*. 2015). Aerial and ground-level photographs of the region taken at different times show that most hillsides were barren and eroded in the mid-19th century and, in fact, other studies show that land degradation was already severe in the 8th century A.D. Historically, there have been a number of cycles of degradation and restoration (see, e.g. Butzer 1981, Munro *et al*. 2008, Nyssen *et al*. 2009). Recently, through exclosures, several previously degraded areas have regained forest vegetation via natural succession. Several studies show exclosures to be efficient tools in terms of vegetation restoration and thereby in soil and water conservation in enhancing water infiltration and stream and ground water recharge, in reducing flood hazards, and in restoring and maintaining plant and wild fauna diversity (Aerts *et al*. 2009, Descheemaeker *et al*. 2006, Mastewal *et al*. 2006, Mengistu *et al*. 2005, Seyoum *et al*. 2015). Exclosures are an important source of animal feed (Yayneshet *et al*. 2009) as well as a potential source of biomass energy. Moreover, exclosures can potentially play an important role in climate regulation by serving as carbon sinks. Over a period of 30 years, the amount of sequestrated carbon reached 246 Mg/ ha (Mekuria and Mastewal 2013). Furthermore, exclosures can help vulnerable communities to increase their resilience by sustaining ecosystems services that provide opportunities for sustainable economic prosperity while providing a defence against the negative effects of climate change (UNEP 2010).

The Government of Ethiopia has planned to increase the area of land under exclosures in recognition of the economic and environmental roles that exclosures could play at the national level. The Climate Resilient Green Economy (CRGE) strategy of the country, which is a national overarching development strategy designed for the upcoming 10–15 years, recognizes protecting and re-establishing forests as one of its four major pillars. The strategy envisages rehabilitation of degraded pastureland and farmlands by converting the lands into exclosures (FDRE 2011). In the CRGE document, the government has set afforestation and re-forestation targets to cover 3 million ha of land by 2030 (FDRE 2011). Exclosures are one of the strategies expected to contribute towards the efforts of achieving reforestation targets.

Successful scaling-up requires a well-formulated strategy based on the best experiences gained from critical evaluations of empirical data and the successes and failures of past efforts.

The aim of this study was therefore to identify institutional, legal and socioeconomic factors that contribute to the success of the forest restoration efforts through exclosures. Such information serves as a key input for developing scaling-up programmes that are responsive to specific socio-economic and ecological set-ups. The main research question that this study attempted to answer is: What are the key institutional, legal and socio-economic factors that contribute to the success and scaling up of exclosures?

Forest status of Tigray

Tigray is a region with a long history of agriculture. Due to its varied topographic features, the region has diverse and distinctive agro-ecological zones. Consequently, the vegetation of the region is diverse, and ranges from Afro alpine to desert types. However, the biological resources of the region have been constantly depleted due to mainly anthropogenic factors. Land degradation resulting from deforestation is a notable phenomenon in the region. Historically, deforestation was started through early settlement and agricultural practices (Argaw 2005). For example, soil erosion caused by vegetation clearing in the highlands of Tigray is believed to have begun in the Middle Holocene (Bard *et al*. 2000, Moeyersons *et al*. 2006). During the Early Holocene, the northern Ethiopian highlands had a humid climate and dense vegetation (Bard *et al*. 2000). Evidence suggests that significant human impacts on northern Ethiopia's Podocarpus–Juniperus forest began about 3 000 years ago (Darbyshire and Lamb 2003). Some of the natural forest remnants (e.g. Hugumburda forest, church forests) indicate that high-canopy forest once covered the northern highlands. The main forest relics of the region are found in protected areas near churches and in inaccessible areas, such as river gorges, which are highly fragmented (Aerts 2006). Forests/dense shrub lands and woodlands cover about 24% of the region's land, while shrubs cover around 27% of the region's land mass (DADPTC 2014). In Tigray, there are five regional state-forest priority areas, and one federal-forest priority area. There are also some forests, such as the Kafta Mesil, that are in the process of being designated as forest priority areas. Tigray's Kafta Sheraro National Park (KSNP) is one of Ethiopia's newest parks, and harbours a wide range of wildlife.

METHODOLOGY

Description of the study area

The study area, the Tigray region, is located in the northernmost part of Ethiopia (Figure 1). Tigray covers a total area of 5 170 225 ha and has nearly seven million inhabitants. Most of the region is arid or semi-arid. The climate of the region is characterized as 39% *Kolla* (semi-arid), 49% *Woina Dega* (warm temperate) and 12% *Dega* (temperate). The three climatic zones, also referred to as agro-ecological zones (AEZs) represent the lowlands, midlands and the highlands, respectively. The total annual rainfall ranges between 450 and 980 mm. About 37% of the region is agricultural land, followed by shrub land (27%), forest/dense shrub land (24%), bare land (10%) and grassland (1.8%) (DADPTC 2014). The vegetation of the region's highlands is primarily Afromontane forests (White 1983). The dominant species in the natural forest remnants are *Olea europaea ssp. Cuspidata* L and *Juniperus procera* Hochst. ex Endl., while *Acacia etbaica* Schweinf., *Euclea schimperi* L. and *Dodonea viscosa* Lf. are the common species in degraded forests and exclosures. Boswellia–Commiphora woodlands cover most of the western lowlands (DADPTC 2014). The study sites, Enda-medihanialem, Rafael, Erbba, Enda-chiwa, Abreha Atsbeha, Ziban Serawat, Mugulat, Gereb Hara and Dabre are located in seven districts (Figure 1) across central, eastern and southern zones of the region. The districts represent the three major AEZs of the region (Table 1).

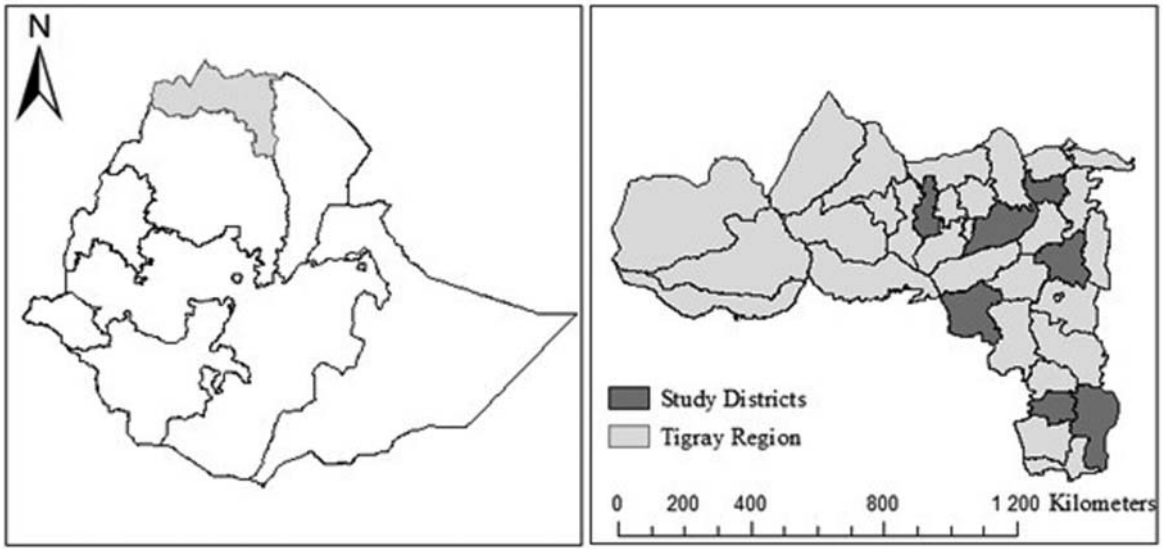
Design of the study

To select successful forest restoration methods that utilize exclosures, some of the basic ecological and socio-economic indicators of community forest management success summarized by Pagdee *et al*. (2006) were used. Accordingly, through a reconnaissance survey and with the help of experts from all

TABLE 1 *Locations and AEZs of the selected sites*

AEZ	Zone	District	Village	Hamlet	Specific site
Lowland	Central	Tankua Abegelle	Shekatekili	Enda-medihanialem	Enda-medihanialem
Lowland	South	Raya Azebo	Karaa-Addishawo	Rafaela	Rafael
Lowland	South	Raya Azebo	Erbba	Erbba	Erbba
Midland	Central	Werie-leke	Enda-chiwa	Enda-Chiwa	Enda-chiwa
Midland	Eastern	Kilte Awlaelo	Abreha Atsbeha	Abreha Atsbeha	Abreha Atsbeha
Midland	Eastern	Kiltew Awlaelo	Agulae	Agulae	Ziban Serawat
Highland	Eastern	Ganta Afeshum	Mugulat	Adi-gidey	Mugulat
Highland	South	Enda Mehoni	Senay	Gereb Hara	Gereb Hara
Highland	Central	Tahtay Maichew	Hadushadi	Amkiho	Dabre

FIGURE 1 *Location of the study districts where the specific study sites are found*



administration levels, nine out of 21 candidate exclosures that are relatively best in terms of mainly biophysical features were selected. Best sites were carefully chosen because future scaling-up requires well-formulated success indicators based on the best experiences. Table 2 presents the indicators used for selection. To identify factors that are responsible for the success of exclosures as forest restoration tools, choices were made based on both literature studies and on jointly selected local factors that are taken as indicators for success.

Data collection and analysis

The methods used to collect data involved review of secondary data, formal socio-economic and biophysical surveys, and consultation meetings and group discussions with local communities. In addition, key informant interviews and group discussions were held with development agents and district and regional experts. Moreover, the technical team visited the sites at different stages of the research process.

TABLE 2 *Indicators used in selecting successful forest restoration efforts through exclosures*

Criteria	Proposed indicators	Means of verification	Indicator used
Ecological			
Agro-ecology	Climate, rainfall, temperature, altitude	Lowland (<1500 m), Midland (1500–2300 m), Highland (>2300 m)	Table 1
Age of the exclosure	Years since establishment (2–5 years minimum, depending on the agro-ecology)	5–10 years, 11–15 years, 16–20 years and >20 years	>20 years for highland 15–20 years for midland 5–10 years for lowland
Types of exclosure practices	• Self-rehabilitation site • With enrichment planting (assisted natural regeneration) • Exclosure with plantation	% planted trees or initial cover (<40%, 40–80%, >80%) Level of intervention (frequency of planting) Every year, every other year, every five years	Self-rehabilitation site with 40–80% plant cover
Cover	In percentage scales (1, 2, 3, 4)	1 = 0–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–100%	4
Vegetation, structural diversity	Vertical structure of the vegetation	No. of strata (1, 2, 3)	2
Plant species richness	Secondary data for species richness	No. of species	10–20 species on average
Erosion risks	Gullies, sheet erosion, rill erosion	No./width/length of gullies, sheet erosion, rill erosion encountered	No. of gullies and rill erosion

TABLE 2 *Continued*

Criteria	Proposed indicators	Means of verification	Indicator used
Downstream impact	Springs/wells, irrigation, sediment load, landslide	Presence/no. of springs/wells, irrigation, sediment load, landslide	1–2 springs, irrigation downstream, no. of landslides
Wildlife	Occurrence, diversity, dropping	No. of wildlife species, new species	>3 species
Soil, physical and chemical properties	Secondary data, indicator plants for soil fertility	No. of indicator species for soil fertility/for degraded soil, studies conducted so far act as sources of secondary data	2–3 pioneer nitrogen-fixing species
Encroachment	Stumps, grazing pressure (cattle droppings), trails,	Are there signs of encroachment?	Zero sign of encroachment
Socio-economic			
Establishment purpose	Achieved or not	With known purpose, achieved or not	Rehabilitation + grass
Proximity	Distance from settlement, market	Distance in km (close, modest, far)	Modest
Ownership, use right	Who owns	Community, government, private	Community
Participation	Level of community involvement, gender, wealth	Mass mobilization, gender participation, wealth inclusiveness, pro-poor	Mass mobilization
Perception	Negative/positive	Any grievance, self-initiated activities, theft	Positive
Income diversification	Outputs from exclosures, marketable and consumable products from exclosures	Annual income for households, consumed products Insurance in case of crop failure	Consumable products
Benefit sharing	Mechanism	Presence of any by-laws; Enforced or not; Fair and equitable access	Presence of by-laws
Employment opportunity		No. of individuals employed	Ready to be distributed to landless youth
Economic importance of species in the exclosure	Economic importance of the species	(bee forage, food, feed) obtained from the exclosure	Bee forage, feed and fuelwood
Institutional and management			
Responsible institutions	Presence, effectiveness	No. of local institutions	Village administration
By-laws	Presence, effectiveness	Enforcement of by-laws	Enforced by-law
Conflict for resource access • within the community • between community/ watersheds/regions	Presence	Presence/frequency, time	Less conflict
Management intervention	Guarding, sylvicultural activities	Presence, number, frequency of pruning and thinning	Guarding

This study was conducted by a team of experts represented by different national and regional institutions. The team began its work by producing a bibliography of abstracts by reviewing experiences on the management of exclosures and protected areas in Ethiopia and elsewhere. Based on the results of the review and also considering regional and national interests, the team developed criteria and indicators to be used in identifying effective practices in establishing and managing exclosures that can be scaled up at regional and national levels. Procedures were developed to assess the impacts of those practices identified as effective on the landscape (biophysical and conservation outcomes) and on the people (livelihood and socio-economic outcomes). A series of regional consultative meetings were conducted in order to

formulate an appropriate design of the study and ensure the views and perspectives of experts in the region were properly and adequately addressed. In addition to experts working at regional offices, local experts and experts from non-governmental organizations (NGOs) working around exclosure sites were included in the consultation meetings. To substantiate the proposed best practices, the study was designed to assess the ecological and social impacts of the selected best practices. This is a vital step, as the ultimate aim of the study is to develop a regional exclosure strategy and a national roadmap.

The consultative meetings, group discussions, key informant interviews and joint field visits conducted at different times were very helpful and constructive in the process of this study. Criteria for setting indicators for best practices and ex ante evaluations for best practices were identified, as were possible improvement measures. The inputs from these consultative meetings with experts helped to frame subsequent steps of the project (i.e. conducting the detailed socio-economic impact assessment, identifying a better type/scale of organizing the community to gain more benefit from the exclosures, and identifying a possible range of management interventions including the challenges and opportunities). During formal consultations with regional and district experts, participants were briefed on the project's progress and were later requested to forward their concerns on the issues raised in the discussions. Small group discussions were encouraged for more comprehensive participation. Checklist-guided formal group discussions were also conducted with senior experts, decision makers and farmers. Field visits were considered as key to examining site-specific conditions and facilitating interaction with the community.

The criteria and indicators used to select effective exclosures as examples of best practice were initially listed by the technical team, based on reviewed documents and personal experiences. Proposed criteria and indicators were presented for expert consultation. Taking experts' comments into account, the revised proposed criteria and indicators were then presented to a regional consultative meeting for comment and confirmation by district and senior experts from government and NGO representatives. The criteria and indictors used for the selection of best practices were thus enriched with comments from various sources.

Cognizant of the need to develop improvement measures for further scaling-up of best practices, the team proposed a list of such measures. These improvement measures were presented to experts in a consultative meeting. Besides group interventions, an individual ex ante assessment of the proposed measures was provided to regional experts. Moreover, proposed improvement options were discussed with farmers through a focus group discussion. Such evaluation is targeted to examine the feasibility of the proposed improvement measures given the different social and biophysical conditions of the studied sites. A standard format for ex ante assessment was contextualized and used to quantify responses of the experts and farmers. Similar discussions were conducted with senior and local experts to identify the strengths, weaknesses, opportunities and threats (SWOT) associated with the scaling-up of best exclosure practices through SWOT analyses.

The socio-economic impact assessment was conducted in the nine selected sites/exclosures using closed and open-ended questionnaires. The questionnaires were prepared based on facts observed during informal assessments conducted through key informant interviews, focus group discussions and SWOT analysis. Interviews were conducted with 324 respondents. Thirty-six respondents were drawn from each of nine villages, with each village representing one of the nine sites where the exclosures are located. The 36 respondents per village were selected using systematic sampling. Distances from nearby towns and wealth categories were considered during the selection of respondents. Questionnaires were pre-tested and adjusted accordingly. The type of questions in the interview and group discussion were mainly focused on: the household characteristics of the respondents; fuelwood and resources endowments; information dissemination mechanism; level of community participation in the planning, implementation and management of exclosures; perception of the community towards exclosures; benefits obtained and benefit-sharing mechanisms; type and method of setting up by-laws; challenges for the sustainability of exclosures; and finally the improvement measures required to scale up exclosures as a forest restoration tool to rehabilitate degraded lands. The data obtained from the interviews and group discussions were analysed using a chi square test and SWOT analysis. The chi square test was run using SPSS version 20 (IBM SPSS Statistics).

RESULTS AND DISCUSSION

Characteristics of the respondents

About 31%, 32% and 37% of respondents for the semi-structured interview were 18–35, 36–50 and >50 years old, respectively. The mean ages of the respondents from the central, eastern, and southern zones were 54.1, 45.5 and 37.9 years, respectively. The age composition across all study sites was more or less similar (Table 3). Most of the interviewees (85%) were married. In all cases, a man was the household head in married couples. Hence, the proportion of male respondents was 85%. About 47% of the respondents had no formal education, 29% could read and write, 18% had completed primary school, and 5% were college graduates. Thus, nearly half of the respondents were illiterate. This implies that although the intervention did not have a written long-term management plan, the farming communities had recognized the potential benefits of establishing exclosures and were able to respect the by-laws set orally.

The respondents' average family size was six. The average landholding of each respondent was about 0.5 ha (Table 3). This is less than the national average landholding, which is 1 ha per household (Kassa and Manig 2004). About 94% of the respondents owned livestock of different types. The number of livestock owned by households was more or less the same across the study sites (Table 3). However, beekeeping is

TABLE 3 *Respondents' family status and ownership characteristics of the nine study sites*

Item	N	Minimum	Maximum	Mean
Age (years)	323	18.0	86.0	43.6
Residence (years)	324	6.0	86.0	40.2
Family size (no.)	324	0.0	12.0	6.1
Land size (ha)	306	0.0	2.5	0.4
Oxen (no.)	324	0.0	4.0	1.3
Cow (no.)	323	0.0	10.0	1.1
Bull (no.)	322	0.0	5.0	0.8
Sheep (no.)	324	0.0	20.0	1.4
Goat (no.)	324	0.0	30.0	1.9
Pack (no.)	324	0.0	4.0	0.8
Chicken (no.)	322	0.0	30.0	3.8
Camel (no.)	241	0.0	25.0	0.5
Beehive (no.)	97	0.0	20.0	2.2

more common in the eastern and central zones than in the southern zone of Tigray. This is mainly due to local agro-ecological suitability of the sites for honey bee flora.

About 95% of the households had wood-lots, although these differed in size, species composition and management status. This implies that households become self-sufficient in domestic wood supply from their own wood-lots. This may have contributed to the success of the forest restoration efforts through exclosures. Similarly, for about 47% of the respondents, the feed sources for their livestock were mainly farmlands. For about 26% of the respondents, feed sources were both farmlands and forest areas. About 16% of the respondent households also had experience of purchasing feed from markets and neighbouring farmers. This has an important implication as it affects the success of forest restoration efforts using exclosures.

Extension and information dissemination about exclosures

The study results show that the local administrators and experts from the Ministry of Agriculture (MoA) have played significant roles in disseminating information on the practices and roles of exclosures. Respondents said that their initial information on exclosures came from these two sources. About 98% of the respondents said that they received adequate information on the role of exclosures from either senior experts/village-level development agents (DAs) from the MoA or local administrators, or both. A considerable number of respondents (35%) had been aware of exclosures for more than 16 years. Respondents mentioned that the awareness-raising interventions also involved field demonstrations of exclosures and their ecological impacts. More than 50% of the interviewees said that they acquired new knowledge and information regarding exclosures through formal training by DAs. Nevertheless, about 30% of respondents indicated that they had not attended any exclosure-related training sessions in recent years. The results of this study showed that NGOs have played little or no role in disseminating information regarding exclosures. Information sharing through social interactions such as neighbourhoods and relatives was not evident from this study based on the respondents' replies when asked whether there was peer-to-peer information flow. This suggests the need to enhance the awareness creation and promotion of exclosures by experts. The regional bureau could ensure awareness through capacity building programmes and incentive mechanisms targeted to boost experts' awareness and commitment. Likewise, although appreciable awareness creation efforts have been made, the fact that about one-third of the respondents had not recently been involved in training indicates the need to do more capacity building through training programmes. Although stronger engagement of technical experts would certainly help the extension, further engagement by local administrators would also be more beneficial, in particular to ensure successful community mobilization for different activities. Regional experts and the local administration can plan and implement exclosure-related extension activities together in ways that are more efficient. Moreover, exploiting cultural information dissemination practices may be necessary to ensure more efficient and effective extension and awareness creation among the community members and to supplement the efforts made by DAs and local administrators. Using local-level traditional institutions such as IDIR and MAHEBER (local-level self-help associations established voluntarily to solve societal problems) can be a strategy for the dissemination of knowledge and demonstration of impacts, and could have a role in promoting and scaling up interventions into areas where there were previously no interventions or where success has been limited. Religious institutions could also play an important role as an entry point to disseminate information and lessons.

Community participation in planning, implementing and managing exclosures

According to the respondents, the experts from the region carried out a significant proportion (33%) of the initiation and implementation of the exclosures. The local communities' and local administrators' contributions to the initiation and implementation process accounted for about 17% each (Figure 2). The results also show that about 62% of the respondents either were consulted by experts from the region or were part of the community group that participated in the process (Figure 2). The level of community engagement during the demarcation phase was assessed as a proxy for the level of community participation in the planning and implementation of exclosures. The result shows that nearly half of the respondents said that the DAs were responsible for the demarcation, while about 30% of the respondents stated that the community had some level of participation together with the DAs (Figure 2). Conversely, about 42% of the respondents indicated that they were not engaged in any decision making about closing a site. Moreover, our data indicated that one-third of the population had participated in the management of exclosures, whether in the form of guarding, enrichment planting, construction of soil and water conservation measures, or the establishment of bylaws. The results suggest that experts from the MoA played considerable roles in implementing the exclosures. The results also imply that most members of the local community participated in the process in one way or another. Considering the future sustainability of the practice, it is important that all groups participate fairly in the exclosure establishment and management process, including women, youth and other marginalized groups. By providing gender awareness training in the initial phase, benefit-sharing schemes will help to ensure full participation (Mekuria *et al*. 2017).

Community perceptions of exclosures

The exclosures provide a wide range of direct and indirect ecosystem services to the local people. However, there is a gap between the actual benefits provided by the exclosures and those recognized by the local people. Above 90% of interviewees agreed that the area of the current exclosures had previously been deforested, which had led to land degradation (Figure 3). Evaluation of respondents' assessment of the productivity (in terms of grass and wood production) of exclosures compared with that of the adjacent unclosed areas showed that about 92% (n = 168) of the respondents agreed that closed areas gave higher productivity. Of those respondents, 77% said that the change in productivity following closure of the areas was significant. The result provided strong evidence that the local community recognized the role of exclosures in increasing site productivity. Assessment of the respondents' impression of changes brought about by exclosures showed that more than 90% of the respondents recognized regeneration of lost species, about 68% of them identified improved grass growth, and about 37% acknowledged reduction of flooding and erosion. The results may suggest a positive attitude of the respondents towards exclosures with regard to the positive impacts in fostering plant growth and improving vegetation cover. This result is supported by Birhane (2002), who found a similar result that 84% of respondents had positive perceptions towards exclosures. Another study done in Ethiopia indicates that 82% of the respondents had a positive attitude about exclosures and felt that they had gained benefits (Mengistu *et al*. 2005). They also showed some level of positive attitude as reflected in each community's recognition of exclosures with respect to their protective roles against environmental hazards such as erosion and flood that are often known to affect downstream communities. Only 7% of respondents mentioned wildlife

FIGURE 2 *Initiation of the practical implementation of exclosures (left) and of demarcation responsibility during the initial stage of closing a site (right)*

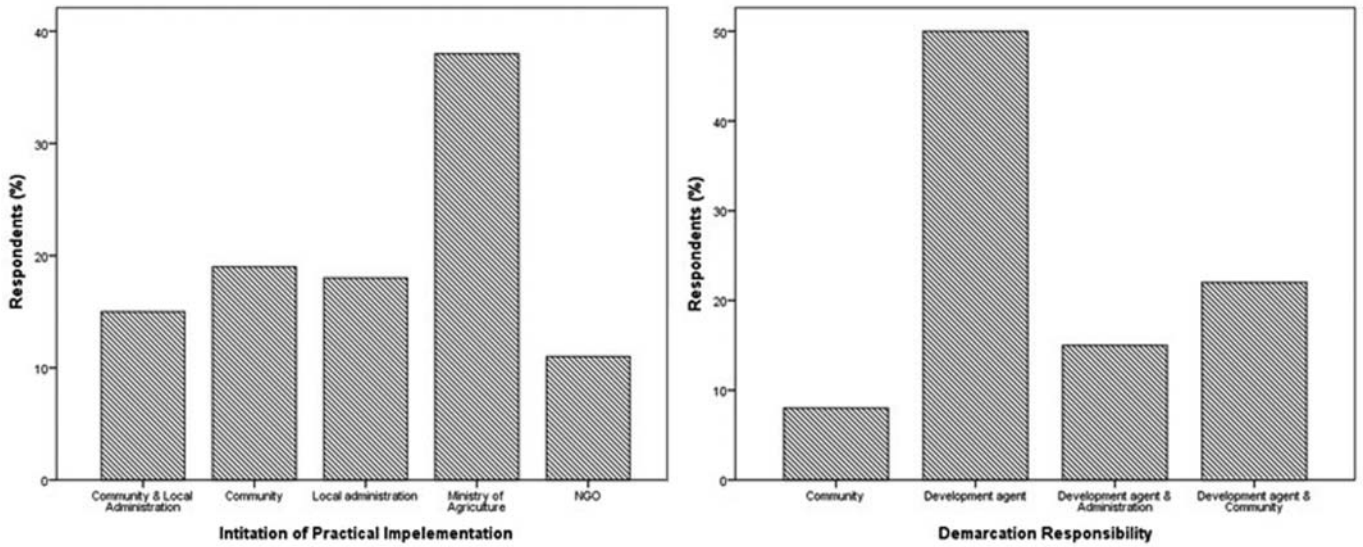
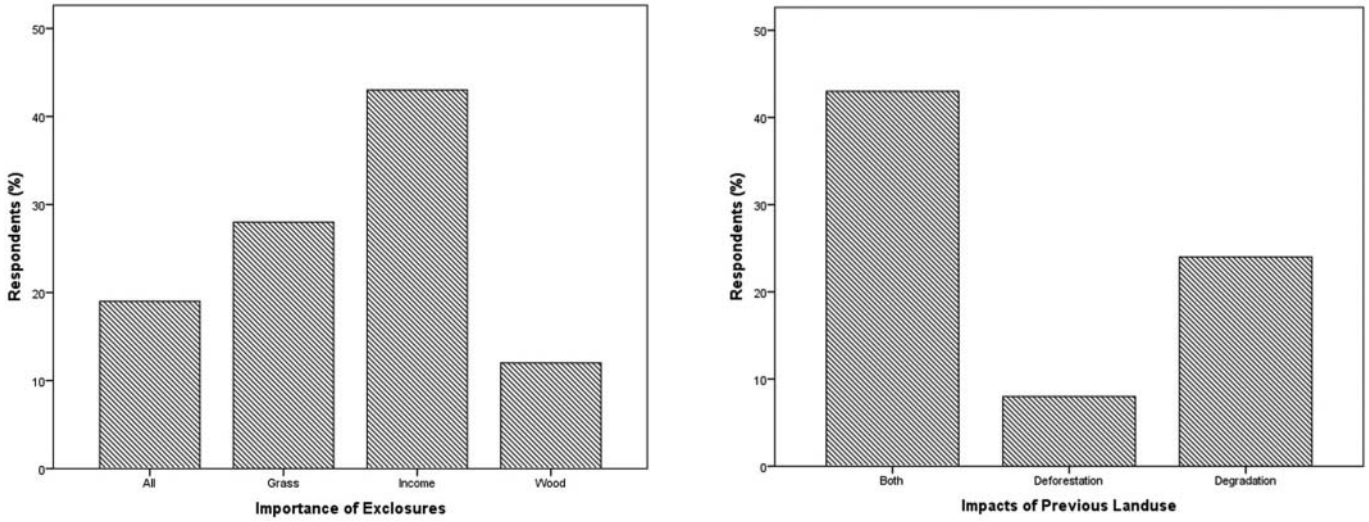


FIGURE 3 *Respondents' replies on the importance of exclosures (left) and effects of previous land use (right)*



re-appearance. However, the communities had not perceived or appreciated the benefits in terms of improvements in wood and water supply after establishment of the exclosures (Figure 4). This may be due to the fact that not all the communities have access to resources, in particular wood products. Consequently, some of the local people perceived exclosure more as an environmental rehabilitation measure than as an economically beneficial practice. Even the environmental rehabilitation benefits gained so far were less appreciated by the community members as compared with the strong success stories advocated and explained by the experts at different levels. This may be because of the difficulty in recognizing the ecosystem services achieved. These results suggest that long-term monitoring will be required to gain an informed understanding of the roles played by exclosures, and the need to communicate the benefits to community members.

We asked the respondents to explain why resources have to be conserved using exclosures. The highest proportion (43%) of the respondents mentioned potential income generation from conserved resources as the most important factor. The second most frequently mentioned answer (28%) was to increase the source of feed (grass) for livestock. However, there was a significant ($P<0.05$) variation in the priorities among respondents from the three geographical zones. Of the total respondents who mentioned increasing the source of grass as a main reason for establishing exclosures, the majority (43%) were from the lowlands. Some respondents (17%) highlighted multiple potential benefits such as income generation, fuel, construction wood and grass as major outputs that should justify conservation. About 85% of the respondents either agreed or strongly agreed with the need to further expand exclosures as forest restoration tools. Only 13% preferred termination of further expansion of the practice. Research done in Ethiopia indicates that the farmers of Tigray had medium to very high perceptions of the environmental importance of exclosures (erosion and flood control, development of springs and increased ground water table levels) (Betru *et al*. 2005). Area exclosure is the dominant type of re-greening practice in Ethiopia and is promoted on degraded lands by the government, NGOs, as well as by multilateral and bilateral donors, whereas afforestation/reforestation is applied to small-scale and industrial plantations (Mulugeta and Habtemariam 2014).

Interviewees who strongly agreed with the positive impact of exclosures accounted for 34% of total respondents, which may imply much more has to be done to ensure broader acceptance of the approach and further extension of the intervention to the wider community. This finding suggests that the purpose of exclosures should be clearly defined, taking the existing major livelihood types into account rather than applying a generic model with a one-size-fits-all approach.

We requested respondents to mention the main problems they faced after the establishment of exclosures. About 35% (n = 168) said that they had encountered no problems, while about 34% indicated the shortage of grazing land (Figure 5). About 27% of them mentioned the shortage of firewood and about 16% of them mentioned crop damage by wild animals.

Benefits obtained from the exclosures

About two-thirds of the households confirmed that, prior to its designation as an exclosure, they used to get various goods and services from such land. The communities in the southern zone benefited more than the communities in the eastern and central zones. However, only 8% of the respondents in the southern zone confirmed that the feed supply had improved after conversion to exclosures; the other respondents either did not respond or considered the benefits they received were not better than before or were almost the same. It seems that there is a higher demand for feed in the low- and high-altitude areas than in the midlands of the southern zone. This is because of the livestock-focused livelihood strategies of the communities in those areas. Communities in the southern zone depend mainly on livestock-based farming systems for their livelihoods (BOARD 2013). This implies that exclosures

FIGURE 4 *The trend of availability of water and feed over the last 5–10 years*

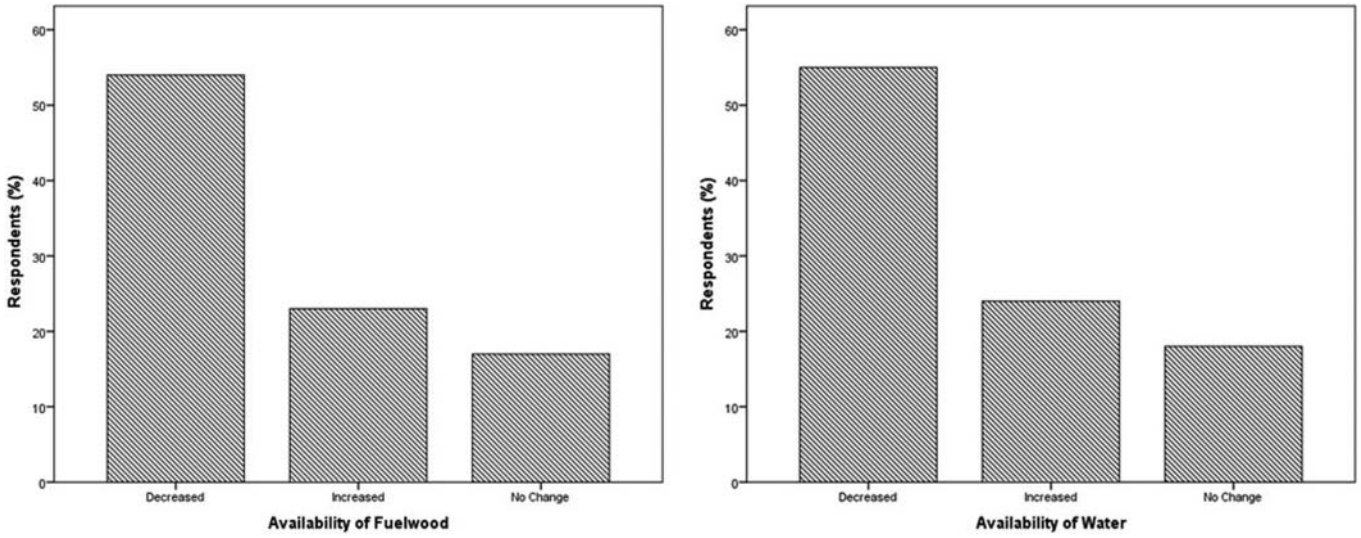
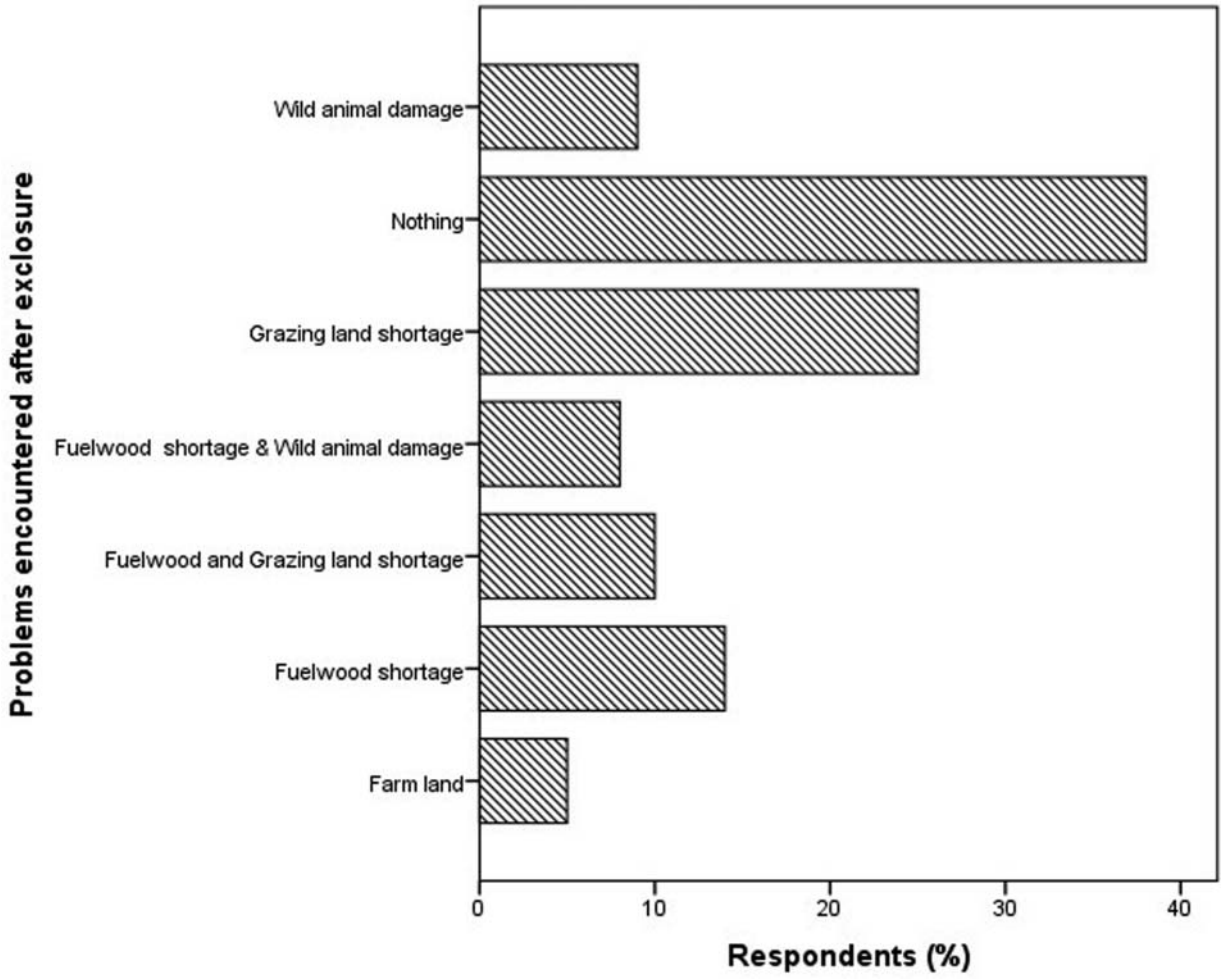


FIGURE 5 *Problems encountered by the local community after exclosures*



might have created critical competition with feed resource supply in the low- and high-altitude areas. The biomass of grass and other herbaceous species in exclosures usually decreases gradually over time as the canopy of trees and shrubs becomes closed. This could also be the reason why the majority of respondents do not think that the supply of grass from exclosures is better than before. This suggests that the exclosures need a management plan that would take into consideration the needs of communities in given localities. Management strategies to improve grass supply may include selective and careful removal of unwanted plants while favouring the economically and ecologically important ones. Such interventions may ensure the sustainable utilization of exclosures protected for long periods in many parts of Tigray.

About 60% of the respondents agreed there was a general improvement in the supply of goods after conversion to exclosures. As a result, diverse woody and non-woody plant species re-emerged, landscape greenness increased, soil erosion declined, sediment deposition downstream declined and water infiltration and stream discharge increased (Babulo *et al.* 2008, Mekuria *et al.* 2011, Yami *et al.* 2006). However, the majority (81%) of the respondents confirmed that they did not have access to any products from the exclosures, including grass and wood. The major challenge in relation to the minimal benefits gained from the exclosures was the prohibition on access to the sites. Although the direct beneficiaries of the exclosures were supposed to all community members as indicated by 78% of the respondents, some of the respondents (11%) complained about the existing benefit-sharing mechanisms. They explained that the benefit-sharing mechanisms were sometimes not transparent. Most of the respondents (60%) agreed on the potential benefits of the exclosures. However, the rest were unsure about the importance of the practice itself. This implies that the focus was only on mitigating land degradation. Conducting enrichment planting of economically important plant species such as fruit trees, bee forage, fodder species and species for fuelwood might help improve the food, feed and energy demands of the local communities, thereby contributing to increasing their incomes and diversifying their livelihoods. However, by-laws should be created to govern harvesting procedures and benefit-sharing mechanisms. On the other hand, there is a need to review the existing by-laws to ensure that by-laws can maintain a balance between benefits that directly support both community livelihoods and rehabilitation of the environment. The meagre benefits obtained so far may suffer from a lack of proper benefit-sharing mechanisms as explained by the communities. This might also be related to the limited knowledge and understanding of a community about the village by-laws that govern the management of exclosures. Such knowledge is essential for empowering the people to claim their rights and adhere to their responsibilities in relation to the rehabilitation of degraded lands.

By-law set-up and effectiveness

By-laws play a significant role in the successes of community-based natural resource management. Most respondents (90%) understood and knew of the existence of by-laws to manage exclosures in their village. About 68% of the respondents said that the community reached an agreement to establish exclosures and they set up the by-laws. About 28% of them explained that the village leaders discussed this with the community which agreed on this course of action. Then the by-laws were set up by the community and enforced by the government. About 5% of them said that the regional government made the by-laws. Only a few said that they did not know how the by-laws were set or the extent of their implementation.

As expressed by most respondents, the by-laws developed for managing the exclosures place more emphasis on protection or conservation than utilization. Several respondents stressed the necessity of amendments, implying that there is a need to set-up clear by-laws for managing, using and protecting exclosures. The discussion with elders on the role of by-laws revealed that many people link the by-laws with penalties when agreed rules are broken, e.g. when people illegally graze livestock. Farmers complained that the modalities of punishment lack clarity and consistency. As a result, they mentioned different figures as fines for similar transgressions. The village bylaws were not effective in meeting the high expectations of users to realize economic benefits from exclosures (Yami *et al*. 2012). Most interviewees responded that the local administrators set the fines. Some elders mentioned that in some cases, exclosure guards determine the level of the fine. This could be a factor as to why some farmers develop a negative attitude towards exclosures. The existence of guards paid by the local office of agriculture and the relatively heavy fines levied to discourage illegal activities inside exclosures had reportedly eroded the support of some community members for forest restoration through exclosures. Thus, some level of illegal activities such as cutting grass and wood were said to occur, often at night or when guards were not around. The majority of the respondents (60%) indicated that there was a certain level of interference by people and domestic animals in the exclosures.

Focus group discussions with elders and also local government experts revealed that most exclosures lack a proper management plan. The current management-related activities relate to only guarding and harvesting grass annually. Of the total number of consulted farmers, the majority (46%) preferred production-focused management plans, while about 37% suggested that even the conservation objective needed to have a management plan. Those who favoured conservation-based management plans thought that production-based management plans would threaten major protective roles of the ecosystem. According to them, any kind of utilization of resources in the exclosures might lead to severe degradation. Some believed that allowing communities to use exclosures would simply destroy them, and rehabilitating the environment needs to be seen as separate from individuals (Gebremichael and Waters 2007). For instance, in Tigray, some 63,000 ha of hillside areas under exclosure so far have been taken from the community and allocated to landless youth to manage and use (Gebresilassie 2013). This, however,

has been identified as a possible disincentive for engaging communities in area exclosure activities in the future. Similarly, in Amhara regional state, about 27,800 ha of state-owned plantation forests on degraded lands have been transferred to the communities that were involved in their establishment and protection (ABoA 2013).

Challenges that limit sustainability of exclosures and suggested solutions for scaling up

To sustain forests restored through exclosures requires appropriate management planning, taking into account the conservation and/or production objectives of area exclosures that were jointly developed with the active engagement of local communities in general and of those managing and using sites under exclosure in particular. Maximizing the economic benefits of exclosure during the restoration phase while still maintaining the conservation goals could be undermined by key challenges, presented below.

Biophysical challenges

In some exclosures, the slow process of rehabilitation was the main challenge. According to the respondents, most of the areas where the exclosures are established have been highly exploited and severely degraded. Moreover, the soil, seed and seedling bank in the exclosures is very poor. In addition to this, moisture stress due to rainfall scarcity and erratic natural phenomena limit the survival of seedlings. Remnant forests are patchy, far apart and degraded. Of all the farmers consulted, about 56% recommended enrichment planting as a way to accelerate the rehabilitation of land under exclosures. Twenty-six percent of farmers preferred direct sowing to planting, as the latter is relatively costly and the survival rate of the seedlings in dryland areas remains low.

In dry areas of Tigray, lack of moisture continues to be a major constraint of ecological rehabilitation efforts. Moisture deficiency results in poor germination, establishment and survival of plants. Therefore, to sustain the restored forests through exclosures, adopting management interventions that augment water-holding potential is necessary. Most of the respondent farmers (70%) said that constructing *in situ* water harvesting structures is a better way to address water scarcity. Of the respondent farmers, 25% preferred to construct water collection structures and to water seedlings by fetching from the collected water. According to the farmers, soil and water conservation measures have both on-site and off-site impacts that include reduction of flooding, siltation and ground water discharge.

Institutional challenges

Well-defined and secure tenure is critical for the sustainable management of natural resources. A number of the sample households (39%) supported the notion of transferring tenure and use right over the exclosures to co-operatives. Their justification was that exclosures have been restored through collective action and its benefits should be shared collectively. They argued that the best tenure for exclosure is for it to be communal and they suggested community-based management as the best management strategy. Farmers in this group feared that individuals might change the land use system. On the other hand, a similar proportion of the sample households (36%) preferred a tenure scheme whereby exclosures should be distributed to individuals nested in co-operatives. Respondents in this group believed that individuals are more efficient than groups. They argued that individuals should be regulated by co-operatives so that individuals did not override the fundamental objectives of conservation. The remaining respondents (26%) preferred the option whereby exclosures would be distributed to individuals. These farmers had the view that individuals could effectively and sustainably manage exclosures and make restored lands even more productive.

Lack of a clear and negotiated benefit-sharing mechanism was also mentioned as one of the challenges. Most sample households (56%) preferred that net benefit sharing obtained from exclosures should be shared equitably among community members. According to them, equitable sharing helps create a sense of ownership and smooth implementation of management plans by community members. Unfair and less transparent benefit-sharing mechanisms degrade the sense of ownership among community members and encourage community members to engage in illegal activities. Some respondents (33%) suggested the need for sharing benefits with vulnerable groups in the community such as landless youth and other disadvantaged groups. About 15% of the respondents recommended a benefit-sharing mechanism that ensures compensation in proportion to the contribution of each individual. Their argument is that a contribution-based benefit-sharing system increases efficiency and guarantees timely contribution of labour and resources for exclosure management.

Another challenge raised by the sample households was rather limited access to the resources in the exclosures. Most of them (73%) suggested recognizing the production objectives of area exclosures and integrating sustainable production and utilization options in the management plan. In the farmers' opinion, the existing way of harvesting grass, which is a cut-and-carry system, as well as beekeeping activities are socio-economically rewarding and ecologically friendly. About 15% of them chose enrichment of exclosures with economically important plant species such as fruit trees, livestock and bee forage plants, and timber trees to improve the economic contribution of exclosures. Those farmers believed that most of the naturally regenerated species within the exclosures are slow-growing indigenous species with less economic importance. However, about 13% recommended selective enhancement of economically important species found in the exclosures. Their argument was that selective enhancement of the native and naturally regenerated species is ecologically suitable. Some are sceptical of the idea of replacing species in the exclosure with more economical exotic species.

Both formal and informal rules and regulations are very important for the sustainable management of exclosures.

Therefore, community-based comprehensive rules and regulations that are binding are required. Most of the respondents (64%) recommended by-laws that are participatory and persuading. They believe that if community members are convinced of the objective and importance of exclosures and agreed on the by-laws, all could work on their enforcement. However, about 28% preferred punitive by-laws. They argued that punitive by-laws are effective in discouraging illegal activities and protecting exclosures. About 8% preferred less-punitive by-laws for exclosure management. According to their justification, less-punitive by-laws are corrective measures that enable experts to teach community members over time, whereas punitive by-laws are harsh and could damage the attitude of community members towards exclosure goals.

CONCLUSION

The results of this study provide strong evidence that the local community recognizes the role of exclosures in increasing site productivity. Many of the respondents recognized that there has been regeneration of lost species, improved grass growth and reduction of flood and erosion after exclosure. However, the positive attitudes and meagre benefits obtained so far are increasingly challenged by the lack of proper and transparent benefit-sharing mechanisms. Moreover, other competing priorities, such as livestock feed, need to be considered while establishing exclosures. The present results show that the local administrators and experts from the Ministry of Agriculture (MoA) have played significant roles in disseminating information on the practices and roles of exclosures. Future scaling-up of the practice might require thoughtful guidelines and an extension manual for greater adoption of these practices and more positive results. Poor participation of especially local communities in the establishment and management of exclosures might compromise results and sustainability. Sustaining the positive impacts of exclosures requires negotiating goals among stakeholders, developing a locally fit management plan enhancing economic returns beyond the restoration phase, and defining clear and negotiated by-laws for use and management including benefit and responsibility sharing mechanisms.

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