

Analysing factors determining the adoption of environmental management measures on the highlands of Ethiopia

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Abstract
A study was conducted on the highlands of Ethiopia to identify and analyse the factors determining the adoption of environmental management measures. In 1985, Ethiopia was classified into low –and high-potential areas based on the suitability of the natural environment for rain-fed agriculture. To address these objectives, case study areas were selected from low-potential and high-potential areas randomly. Data were collected through face-to-face interview and key informants, focus group discussion and field observation. In the low-potential areas, the physical environment – particularly soil and forest environments have shown substantial recovery. Similarly, the water environment has improved. However, in the high-potential areas sampled, these resources are still being degraded. Clear understanding of the benefits of soil conservation structures by farmers, active involvement and technical support from the government and full and genuine participation of farmers in communal environmental resources management activities were found to be main factors in the adoption of environmental management measures.
Keywords: Ethiopia, environmental management measures, adoption

1. Introduction

The environment includes water, air, land, and living creatures such as plants, microorganisms, and animals (Garg and Garg 2006). For convenience, environment has been classified into natural and human components. The natural environment includes the physical and biological environments, which are the basis for the well-being of human populations. As a well-managed natural environment is the basis for sustainable development; management of the natural environment has become the main concern of the Ethiopian government since the 1970s. In Ethiopia, the environmental movement started in the 1970s, as a result of the 1973-1974 famine (Dessalegn Rahmato 1998). The aim of the movement was to reduce environmental degradation – especially soil erosion and deforestation – and boost agricultural productivity and food security. With a focus on these objectives, the government of Ethiopia began undertaking major environmental management activities, such as the creation of Soil and Water Conservation (SWC) structures on cultivated lands, planting and water harvesting on non-cultivated lands (Girma Tadesse 2001). Therefore, this paper focuses on the natural environment, particularly soil, forest and water environment.

1.1 Overview of environmental history of Ethiopia

Historical sources concur that the Ethiopian Highlands had a much greater forest and woodland cover in the past. About 40% of Ethiopia, particularly its highland areas, was once covered by forest, while its lowland areas were covered by bushes and shrubs. However, the forest cover of the country was reduced to 16%, 3.6%, and 2.7% by 1950, 1980, and 1989, respectively (Bekele Million and Berhanu Leykun 2001). On the other hand, Nyssen et al. (2009) compared northern Ethiopia's vegetation cover in 1868 and 2008 – by examining historical photographs – and concluded that the area was degraded prior to the 1860s. This supposedly thick forest cover was destroyed as a result of ever-increasing demands for firewood, construction poles, farm implements, and crop and grazing land to accommodate rapid population growth.

Cognizant of the problem, the governments of Ethiopia took several measures to address it. Although the country has a long history of tree planting activities, which started during the reign of King Zera-Yacob (1434-1468), a modern tree planting programme (e.g., eucalyptus trees) was started in 1895 by Emperor Menelik II for several purposes (Yitebitu et al. 2010). In contrast, historic rapid expansion during mass mobilization in the Derg regime (1974-1991) resulted in large-scale and community-level plantations that still exist in various parts of the country. Since 1991 the government of Ethiopia has maintained the emphasis on the forest sector and has taken substantial legal steps towards management and plantation, such as the ratification of a new forest policy and creation of a forest proclamation (EPA 2012). The government has also introduced an annual tree planting campaign throughout the country in which every person is encouraged to participate, with the goal of influencing the population's attitude towards trees (Asnake Mekuriaw 2014). Ethiopia has made substantial progress in tree planting (EPA 2012), and, consequently, the country's forest cover has increased from 2.7% to 6.1% (8.8 million ha) (MoFED 2010). Although the forest coverage has expanded, the total is still far below the global average (31%).

Regarding soil, soil erosion is a problem in many parts of the world (De Graaff et al. 2008 in Europe (Wauters et al. 2010), in the Midwest of America (Zhou et al. 2009), Bolivia (Kessler 2006), Peru (Posthumus and Stroosnijder 2010), Tanzania (Tenge et al. 2005), and China (Heerink et al. 2009). Similarly, in Ethiopia soil loss due to water erosion is very high and has emerged as the country's most serious environmental problem in recent decades. Over the last three decades, the country lost over 1.5 billion metric tonnes of topsoil annually due to erosion (Hurni 1988), and now it losses 980 million metric tonnes of topsoil annually (Kaspar et al. 2015). Today, soil erosion is severe on Ethiopia's agricultural land (Hurni et al. 2010). The consensus emerging from the available literature is that the rate of soil erosion in Ethiopia is high and that it presents a serious obstacle to sustainable agricultural development in the country as it harms the structure and nutrient content of soils.

The Ethiopian government first recognized the impact of soil degradation after the 1973-1974 famine, which occurred in the highly degraded parts of the country, Tigray and Wello. Immediately, the government started SWC campaigns to combat severe soil degradation and hence to ensuring food security and improving the livelihood of the population (Dessalegn Rahmato 1998; Nigussie Haregeweyn et al. 2012). Traditional SWC measures in some areas show that soil erosion and ways to prevent it have long been a concern to Ethiopian farmers (Mahid Osman and Suerborn 2001; Nyssen et al. 2007).

Since 2011, the government of Ethiopia instituted a national physical SWC construction campaign that runs for two months (January and February) every year throughout the country. The campaign is aimed at mobilizing the community to construct the necessary structures following watershed conservation principles. To implement the programme, a watershed is selected from every kebele (the smallest administrative unit) by the local development committee, the Development Agents (DAs), and the community. Then the necessary SWC structures are constructed by the community of the kebele under the supervision of the local DAs. However, the achievement is below the anticipated (Asnake Mekuriaw 2014).

Regarding water resources, the number and magnitude of springs and rivers and the great amount of annual rainfall could make the Ethiopian Highlands rich in water resources. Awulachew et al. (2007) reported that Ethiopia has an estimated annual runoff volume of 122 billion m^3 of water and about 4.55 billion m^3 of ground water potential. It is clear, however, that the amount of water is influenced by natural topography, variability in climatic factors, land management practices, and human activities. When water resources are degraded, other land resources (vegetation, soils, terrain, and climate) as well as socio-economic activities, particularly agricultural activities, are also affected. Since 2004 several water management measures (rainwater harvesting, upstream/stream head development, etc.) have been practiced in Ethiopia.

1.2 Objectives

In Ethiopia, environmental management measures such as SWC measures, plantation and water resources management have been practiced for nearly 40 years in certain parts of the country, demonstrating good success in some cases. However, the adoption at regional level is below anticipated. The factors behind the adoption and success of environmental management measures practiced have not been thoroughly identified and analysed. Besides, there was a need to know how farmers of the Ethiopian Highlands think about their environment and what changes they have recognized over the decades. Therefore, this paper aimed to identify and analyse the factors influencing for the adoption of environmental management measures in the Ethiopian highlands.

2. Materials and Methods

2.1 Study area

Because the Ethiopian Highlands had previously been classified into low-potential and high-potential agricultural areas (RRC 1985), these designations were used to select case study areas. The Tigray and Wello regions are typical areas with a low agricultural potential (RRC 1985; Benin 2006), whereas the Gojam district is known for its high potential (RRC 1985). Therefore, a total of sixteen case study areas (eight in Wello and Tigray and eight from Gojam) were selected (Figure 1). As in other parts of the country, the population in these areas depends on agriculture, mainly crop production and livestock husbandry.

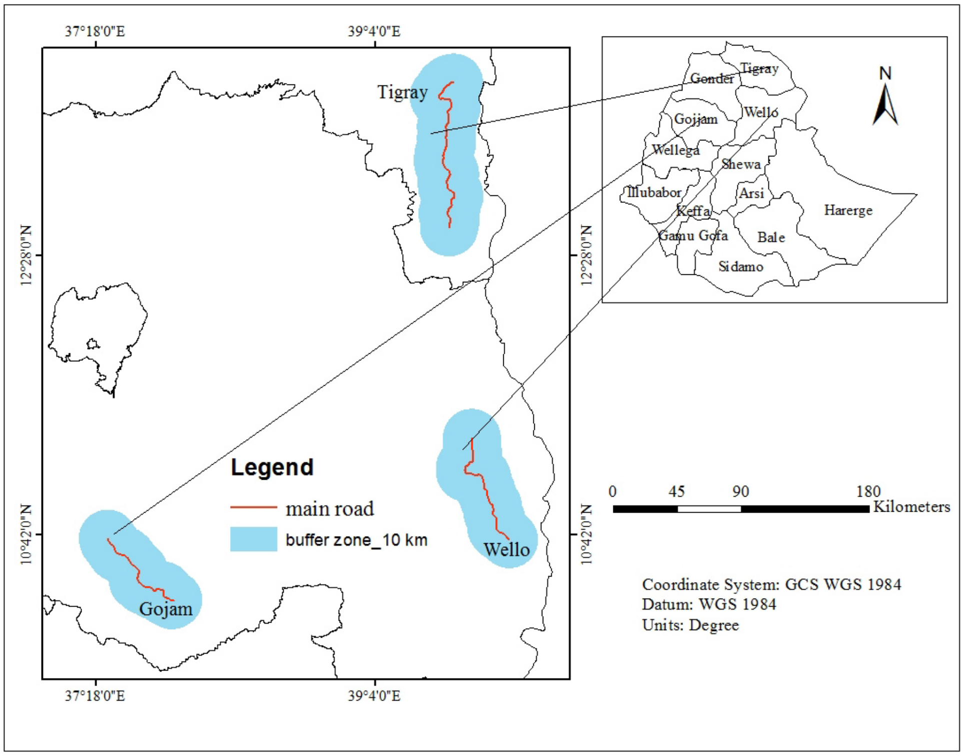

Figure 1. Location map of the study area.

2.2 Methods of data collection

In this study, both primary and secondary data was used. Secondary data was collected from the respective offices including agriculture office, environmental protection and land administration office, water resource development office. Primary data was collected using face-to- face interview, focus group discussion, key informants and field observation. The necessary socio-economic and environmental data was collected from respondents using a structured questionnaire.

At each case study area, the local DA and respective village administrator who knew the area, the community, and the environmental management practices provided assistance during data collection. A total of 269 respondents (94 from Gojam and 175 from Wello and Tigray) were then randomly selected. Then data were gathered through face to face interview. Focus group discussions were conducted with the community, as were discussions with the respective DAs and other experts. Field observation provided another source of data.

2.3 Methods of data analysis

The study included both qualitative and quantitative research methods. Qualitative data was partially analysed during data collection to immediately fill any gaps through subsequent data collections. The quantitative data was analysed using appropriate statistical procedures based on the level of measurement of the variables involved. SPSS (version 16.0) (IBM SPSS Statistics, Armonk, NY) was used to obtain descriptive statistics, frequencies, averages, cross-tabulation, and non-parametric statistics (χ^2 test). The results were then analysed with respect to selected parameters.

3 Results

3.1 Farmers perception on existing environmental conditions of the highlands of Ethiopia

Farmers were asked to evaluate the current status of their local natural environment because they are the primary actors capable of managing or destroying the environment and are most apt to properly recognize changes and the reasons behind them. They were asked to assess the current status of the local environment using three terms: Degraded, Improved, and No Change. These terms were chosen on the basis of experience gained during the pre-test and field visits. Table 1 presents the perceptions of farmers who believe that the status of their environment has either improved or degraded. The response for No Change ranged from 0% to 4% and was thus too small to be included in the table.

Table 1. Farmers' perception of the current status of the natural environment in the Ethiopian Highlands.

Environmental Variable	Current Status	Percentage of Respondents		χ^2 (p-value)
		High-Potential Areas	Low-Potential Areas	
Soil	Degraded	98	7	2.145
	Improved	1	93	(0.001)*
Forests	Degraded	98	11	1.88
	Improved	2	87	(0.001)*
Water	Degraded	97	33	1.03
	Improved	2	63	(0.001)*

High-potential (n = 94) and low-potential (n = 175) areas in the Ethiopian Highlands;* Shows significance at $p \leq 0.001$.

In the high-potential areas, 98% of the interviewed farmers and all the farm household heads involved in focus group discussions believe that the soil has degraded and the fertility has declined over the last decades and that some plots of farmland are suitable only for certain crops. On the other hand, 93% of interviewed farmers from low-potential areas reported that the soil environment in their area has improved. They stated that nearly three decades ago, the soil was degraded and infertile and was suitable for only certain crops. However, over the last three decades, they have been practicing and maintaining SWC structures, and thus the fertility has improved. Consequently, the land is now suitable for many types of crops. When the responses of farmers from the high-potential and low-potential areas are compared, the difference in their perceptions of soil status is significant ($p \leq 0.001$, $\chi^2 = 2.145$).

In the high-potential areas of the Ethiopian Highlands, 60% and 53% of the interviewed farmers indicated that topography and lack of SWC structures, respectively, are main causes of soil degradation. Additionally, 36% and 43% of the respondents felt that damaged SWC structures and free grazing, respectively, have contributed to soil degradation (Table 2). On the other hand, farmers interviewed in low-potential areas pointed out that even though soil erosion is not their main problem, the topography (cited by 98%) and intensive cultivation (cited by 93%) have worsened it. Birru Yitaferu (2007) pointed out that soil erosion in the highlands of Ethiopia is largely attributed to the cultivation of steep slopes. Similarly, Aklilu Amsalu (2006) found that topography, erosive rain, damaged conservation structures, and tillage practices were the main causes of soil erosion in the Ethiopian Highlands. Girma Tadesse (2001) and Schmidt and Tadesse (2012) explained the Ethiopian Highlands' high vulnerability to soil erosion with fragile soils, undulating terrain, heavy seasonal rains, and deforestation due to farmland expansion. Only 15% of the respondents identified free grazing on cultivated land as the main cause of soil erosion.

Table 2. Farmer's perceptions about the causes of environmental degradation on the Highlands of Ethiopia.

Environmental Problem	Cause of Degradation	Respondents (%) Who Agreed	
		High-Potential Areas	Low-Potential Areas
Soil erosion	Lack of SWC structures	53	1
	Damaged SWC structures	36	0
	Topography	60	98
	Intensive cultivation	24	93
	Free grazing	43	1
	Erosive rainfall	10	0
	Deforestation	23	10
Deforestation	Firewood	96	10
	Charcoal making	1	1
	Construction poles	5	0
	Fencing	94	10
	Expansion of cultivated land	61	2
Water resource depletion	Expansion of cultivated land	66	2
	Deforestation	93	11
	Change in rainfall amount	25	30
	Eucalyptus tree plantations	25	30

High-potential (n = 94) and low-potential (n = 175) areas in the Ethiopian Highlands. For each environmental problem, the percentage of respondents exceeds 100% because of multiple responses.

Concerning the status of forest environments (excluding eucalyptus trees), 87% of the interviewed low-potential area farmers pointed out that the vegetative cover in their area has improved over the last two decades. Similarly, a study conducted in the low-potential areas by Nyssen et al. (2009) found an expansion of forest cover. On the other hand, 98% of the high-potential area farmers felt that it has degraded. In contrast, 87% of the farmers interviewed in the low-potential areas thought that the vegetative cover had increased because of forest management practices adopted across the area. When perceptions of the current status of vegetation are compared between farmers from low- and high-potential areas, the difference is significant ($p \leq 0.001$, χ^2 = 1.88).

Ninety six per cent, 94% and 67% of the respondents identified either cutting of vegetation for fire wood or cutting of vegetation for fences and expansion of cultivated land, respectively as the primary contributor (Table 2). It should be noted that cultivation of eucalyptus trees has become a profitable business, and thus many homesteads have become eucalyptus plantations, consequently increasing the vegetative coverage substantially. Nearly a quarter of the survey respondents indicated that deforestation has resulted from expansion of cultivated lands. Nearly all the farmers involved in focus group discussions noted that destruction of forests and vegetation took place primarily during the 1970s and 1980s with expanded crop cultivation. Similarly, a case study conducted in the highlands of central Ethiopia showed that within 33 years farmlands expanded by 100%, with growth coming at the expense of vegetation (Efrem Garedew et al. 2009).

Regarding water environment, 97% and 33% perceived that the water resource in the high-potential area and low-potential area, respectively has declined over the last decades. When we refer to water resource degradation, we do not mean that water resources (ground and surface) are scarce in the Ethiopian Highlands; rather, the term is used to indicate the availability and accessibility of water for farmers in time and space, depending on the available technology at the moment, and to compare the current water resource situation with the previous one. Accordingly, water resource degradation includes the drying of streams, springs, rivers, and reservoirs; changes in run-off; sedimentation of water bodies; and decline in water quality. In the high-potential areas, deforestation and expansion of croplands to water sources were mentioned as causes of water scarcity by 93% and 66% of the respondents, respectively. Both change in rainfall amount and planting of eucalyptus trees at the head of springs were identified by 25% of respondents in high-potential areas and 30% of respondents in low-potential areas as having substantially reduced the number of water resources.

On the other hand, close to two-thirds of farmers interviewed in the low-potential area believe that water resources have improved because of the expansion of vegetative cover and maintenance of SWC measures. There was a significant difference in the perception of the water environment between farmers from high-potential areas and those from low-potential areas ($p \leq 0.001$, χ^2 = 1.03). Generally, the natural environment (specifically the soil, water, and forests) of the sampled low-potential areas has improved over the last decades. However, all three environmental resources have degraded in high-potential areas.

3.2 Environmental management practices

Identifying the type of measures being practiced and understanding when and where farmers undertake particular practices based on what they know and perceive is important for promoting sustainable environmental resource management. To gain insight into these issues, the necessary data were collected using both socio-economic survey data (Table 3) and field observations.

3.2.1 Soil resource management

In the low-potential areas, 94% of the respondents and all of the farmers involved in the focus group discussions indicated that they have been willingly practicing and maintaining SWC structures since the 1970s on all cultivated lands that required intervention, primarily to keep the soil in place and thereby improve crop productivity and also to produce fodder for their livestock. The 6% of farmers who were not using SWC structures said it was because their farm land is flat. Cut-off drains and ditches were used by 94% and 77% of survey respondents, respectively, to protect against soil erosion. Surprisingly, none of the respondents were practising fallowing; rather, 98% of the farmers interviewed and all of the farmers involved in the focus group discussions practise crop rotation, while 59% of the respondents use compost.

In high-potential areas, 56% of respondents indicated that even though the idea of SWC was introduced in the 1970s, they began practicing the structures only in the last decade. Although 44% were not using SWC measures, a total of 92% of respondents were using ditches during normal field operations as a soil conservation measure, whereas 81% use cut-off drains. To improve the fertility of their soil, 94% of respondents practise crop rotation, while 77% use compost. Only 4% of respondents are fallowing the land to improve its fertility. However, after looking at their cultivated land, we asked farmers why they were reluctant to construct and maintain SWC structures despite understanding and appreciating their benefits. About 44% of them ultimately demolished the structures, thinking they had no value and were a waste of limited land for cultivation. Some of the farmers involved in focus group discussions also felt that SWC structures had no significant value.
Generally, the majority of the farmers interviewed in the Ethiopian Highlands use physical SWC structures to prevent soil erosion. To improve soil fertility, farmers throughout the Ethiopian Highlands practice crop rotation. However, when we compare responses from farmers in the two areas, farmers in the low-potential regions were more aware of the multiple uses of SWC structures.

Table 3. Environmental management practices in the highlands of Ethiopia.

Environmental variables	Management Practice	Respondents who participate in the activity (%)	
		High-potential areas	Low-potential areas
Soil	SWC structure	56	94
	Cut-off drain	81	94
	Ditch	92	77
	Fallowing	4	0
	Composting	77	59
	Crop rotation	94	98
Water	Water harvesting	35	26
	Protecting water points	83	14
	Watershed management	47	27
	Planting of water-generating trees	95	11
Vegetation	Area closure	82	6
	Plantation	94	11

High-potential (n = 94) and low-potential (n = 175) areas in the Ethiopian Highlands. For each environmental variable, the percentage of respondents is greater than 100% because of multiple responses.

3.2.2 Water resource management

To cope with the impact of water scarcity and also to produce better yields, farmers are currently using a variety of management systems. When asked how farmers of the high-potential area manage the water resources in their area (Table 3), 95% of respondents reported that they have cultivated water-generating plants (such as *Ficus vasta, Croton macrostachyus, Cordia africana, Albizia gummifera, Mimusops kummel,* and *Ficus sycomorus)* at the head of springs. Eighty three per cent of respondents indicated that they are practising watershed management, based on the belief that green areas can generate clean and increased amounts of water, and are also protecting the head of springs by removing eucalyptus trees and encouraging farmers with land near springs and streams to leave a buffer zone. Nearly 30% of the respondents indicated that they have constructed water-harvesting structures to store water for the long run, particularly for the dry season.

In contrast, farmers in low-potential area are emphasizing water harvesting activities and watershed management. More than a quarter of them reported that they have been practising rainwater harvesting since 2004, particularly retaining run-off in ponds and collecting roof water in small-reservoirs (Figure 2) for use during the dry season. In addition, they are practicing watershed management in areas where streams are generated.

Most of the farmers involved in the focus group discussions indicated that competition for irrigation water occurs in the dry months of November to May, when much of the water resource has left the highlands and when rivers and streams cannot satisfy domestic uses. During this time, there have been conflicts between upstream and downstream farmers, even within a single village. However, this problem has apparently been solved because the respective farmers have established a committee called the Father of Water. The Father of Water prepared a customary agreement governing the sharing of spring and stream water for different purposes, including supplementary irrigation. The committee also manages utilization of available water resources within the villages as well as between upstream and downstream villages.

Figure 2. Photograph showing a water harvesting system in Tigray, a low-potential area (Asnake Mekuriaw, May 2012).

3.2.3 Forest resource management

The farmers in the Ethiopian Highlands were asked how they manage the vegetation in their area (Table 3). In the high-potential areas, farmers have been practicing plantation (cited by 82%) and area closures on communal land (cited by 94%). However, the plantation sites were identified and selected by the local development committee without consultation with the wider community, and thus the survival rate of seedlings has been far lower than anticipated because of lack of attention by the local population. In contrast, sites for area closures were selected in consultation with the local people; consequently, the vegetation is recovering and the progress is promising because all communities agreed on the basic idea and participated in the entire process.

In the low-potential areas, 11% and 6% of the respondents were maintaining area closures and plantings, respectively. This is because, since 2005, all of the communal vegetation areas have been given to youth associations, which did not have farmland, to protect the vegetation and utilize the resources, including the grasses grown inside the vegetation area. With technical support of the officials, the youth associations developed by-laws stating that if a person cuts a tree for the first time, s/he will be penalized USD 2.60 per tree and will be required to plant at least two trees at the same location. If the same individual is caught cutting down trees a second time, s/he will be penalized USD 5.20 per tree and will face imprisonment for three months.

4. Discussions

In the Ethiopian highlands, environmental management measures such as SWC, plantation and water resources management have been practiced since the 1970s.

4.1 Soil and water conservation measures

In the Ethiopian Highlands, physical SWC measures such as soil/stone bunds, cut-off drains, waterways, and ditches have been applied to reduce and hence to manage soil resources. The socio-economic survey results revealed that the majority of the households sampled were using physical SWC structures to keep the soil on their cultivated land and to improve crop yields. In the sampled low-potential areas, all cultivated lands that required intervention have been terraced. Households consider the physical SWC structures to be necessary for survival and have maintained them over the years. They have also used these structures on non-cultivated lands. Consequently, the soil has been improved and is suitable for many crop types, which was not the case before the adoption of SWC structures. Similarly, a number of empirical studies examining the effectiveness of SWC structures in low-potential areas indicated that the structures have benefited productivity and ecosystem services. In Tigray physical SWC structures constructed on farmlands reduced soil loss by water erosion by 61–68%(Nyssen et al. 2007), in Tigray and Wello physical SWC structures increased the average crop yield by about 42% (Benin 2006), by an average of 23% (Pender and Gebremedhin 2006). In Tigray showed that intensive use of SWC measures in the upper parts of a watershed significantly contributed to the development of wetlands in the lower parts (Fikir Alemayehu et al. 2009).

Nevertheless, farmers in the high-potential areas acknowledged that soil erosion damages cultivated and grazing lands and consequently affects crop yield and livestock production. Although they clearly observed soil erosion and understood its impact, many of the households sampled have not built physical SWC structures because they do not perceive a significant advantage to their use; instead, they see these measures as a waste of limited cultivated land. Investments in physical SWC structures have provided higher economic returns and have had a greater impact on productivity in low-potential areas than in high-potential areas (Kassie et al. 2007). In high-potential areas, physical SWC structures were not associated with productivity gains (Kassie and Holden 2006), and may not pay off at the farm level, but control of run-off and soil erosion provides social benefits (Nyssen et al. 2004).

4.2 Forest resource management

Forests in Ethiopia have been cleared for crop production, firewood, and construction materials, leading to serious environmental and socio-economic problems. To rehabilitate the degraded landscape and provide the required firewood and other services, the Ethiopian government has launched afforestation campaigns throughout the highlands, where the rate of deforestation was very high and most of the population has settled. Aware of the trend of deforestation, the Ethiopian government encouraged farmers in the low-potential areas to plant different species and to actively manage the available resources. In addition, the people have established various rules and regulations governing maintenance of and accessibility to available forest resources. When someone violates the rules by cutting or collecting wood from a protected area, s/he has to replant at least double the amount taken. The degraded communal lands have been given to the youth association for the planting of trees, protection of vegetation, and use of available resources, including the grasses grown inside the area. Consequently, in the sampled low potential area the vegetative cover has increased. In the northern part of Ethiopia (i.e. Wello and Tigray), hillsides were distributed to individual land users for plantation and, consequently, remarkable achievements such as the Desse-Maychew road have been completed (Danano 2002).

In the high-potential areas of the Ethiopian Highlands, plantation was common during the Derg regime; after 17 years (i.e. since 2008), the majority of sampled households (more than 82%) are again maintaining plantation sites and area closures. However, the plantation sites were identified and delineated by the local development committee without consulting the wider community, which contradicted the community-based environmental resource management approach. Most of these areas had been an important source of pasture for cattle grazing; thus, most people have a negative view of the communal planting programme because it ultimately decreased available grazing lands. Consequently, the survival rate of seedlings has been far lower than anticipated, as the local people have not taken ownership of the effort. In contrast, the area closure sites were selected in consultation with the local people, who agreed with the basic idea behind them and participated throughout the process; thus, the vegetation in these sites has been recovering and progress has been promising.

It should be noted that private tree plantations are another important focus of forest management practices. All participants in the focus group discussions reported that nearly all farmers have planted trees in the farm fields and around homesteads. During a field visit, eucalyptus trees were observed on most homesteads as well as on degraded lands, which are characterized by poor soil quality and soil erosion. Farmers are aware of the various benefits of eucalyptus versus indigenous trees and now use eucalyptus for firewood and construction of houses and as a cash crop. Such activities could facilitate the regeneration of indigenous trees. In the Ethiopian Highlands, forest resources have (recently) generally improved (due to eucalyptus tree planation) since under the current administration. However, the improvement is most apparent in the low-potential areas, where the government has given special emphasis to the effort.

4.3 Water resource management

In the literature, it is common to find claims that "the Ethiopian Highland is believed to be rich in rainfall" and is the "water tower region of the Horn of Africa". It should be noted, however, that *available* water does not necessarily mean *accessible* water. Although farmers in this area understand the importance of irrigation for improving their livelihood, available water resources are not always accessible to poor residents. Often, farmers must compete for water resources, particularly during the dry months of November to May, when much of the water has left the highlands and rivers and streams cannot satisfy domestic demands for irrigation.

To manage water resources, farmers of the high-and low-potential areas have used different systems such as planting water-generating plants at the head of springs, practicing watershed management, and protecting the head of springs by enforcing regulations requiring farmers to leave a buffer zone around springs and streams and by removing eucalyptus trees, which have high water requirements. In contrast, farmers in the low-potential areas have emphasized water harvesting and watershed management.

4.4 Main factors determining the adoption of environmental management measures

The factors that determine the adoption of environmental management measures are discussed below.

4.4.1 Lack of awareness on the importance of environmental management measures

This study showed that most farmers of the Ethiopian Highlands understand the trend and current status of their environment. Understanding of the history and extent of environmental problem is the most decisive factor in the acceptance, practice, and maintenance of conservation measures (Hagmann et al. (1997). Although farmers in the Ethiopian Highlands understand the history and current status of their environment, significant differences in acceptance of environmental management measures were found between the high-potential and low-potential areas. This disparity is due to the fact that farmers in the low-potential areas have more knowledge and better understanding of the environment and its impacts and of the importance of practicing management measures than do farmers in the high-potential areas. For example, unlike their counterparts in the high-potential areas, farmers in the low-potential areas have been strict about applying the rules and regulations concerning environmental management. Clear understanding of the benefits of environmental management by farmers is found to be main factor in the success of environmental management efforts. Therefore, changes in the attitudes of farmers through field visits are necessary steps for the adoption of environmental management measures throughout the Ethiopian Highlands.

4.4.2 Lack of strong governmental involvement

Since the 1970s, the government of Ethiopia has given priority to the low-potential areas, which have thus been able to practice environmental management measures properly. Researchers indicated that because of environment degradation (soil, vegetation, and water), affected farmers in the low-potential areas (e.g, Tigray) were mobilized and supported by local and international NGOs in applying environmental management practices (Nyssen 1998). Consequently, in the sample low-potential areas, the natural environment (i.e. soils, forests, and water) have improved over the last few decades. However, in the high-potential areas where the government has placed little emphasis, the natural environment has degraded during that time.

4.4.3 Top-down approach

In the Ethiopian Highlands, environmental management activities (e.g., SWC, forest and water resources management) have been delegated to the Wereda Agricultural Office. In reality, the office staffs have been following a top-down approach to the design and implementation of these measures. Proper management of the natural environmental requires the full participation of all concerned institutions from the planning stages to the monitoring stages (Thilahun Amede et al. 2007). Community-based natural resource management can succeed, when both the internal and external factors influencing it are identified (Armitage 2005). In the central highlands of Ethiopia many farmers had either totally or partially removed these SWC structures (Bekele and Drake 2002) because they had not been involved in the design and implementation stages and hence had not properly integrated them into their farming systems.

5. Conclusions

In the Ethiopian Highlands, a variety of environmental management measures are practised, primarily creation of

SWC structures, water harvesting, watershed management, planting of water-generating trees, and protection of water points. Area closures and plantings are strategies for managing forests on communal lands. Lacks of awareness on the importance SWC measures, top-down approach on plantation site selection and emphasis from the government side are the main factors determining the adoption of environmental management measures. Therefore, to manage the environment properly the government should follow community based environmental management, creating awareness on the importance of environmental management for sustainable development and focus on both the high- and low-potential areas.

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