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Factors influencing the adoption of physical soil and water conservation practices in the Ethiopian highlands

Asnake Mekuriaw [a,*], Andreas Heinimann [b], Gete Zeleke [c], Hans Hurni [b]

[a] Department of Geography and Environmental Studies, Addis Ababa University, PO Box 1739, Bahir Dar, Ethiopia
[b] Center for Development and Environment, University of Bern, Switzerland
[c] Water and Land Resource Center, Addis Ababa, Ethiopia

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ABSTRACT

Soil and Water Conservation (SWC) structures have been constructed on cultivated land for nearly 40 years to reduce soil loss and improve crop yields and people's livelihoods in the Ethiopian highlands. However, the success of this huge effort has been mixed, and the main constraints have not been investigated in detail. This study was undertaken to identify the factors determining the adoption of SWC structures in the Ethiopian Highlands. Case study areas were selected from high-potential and low-potential areas. Data were collected from 269 farmers using face-to-face interviews, and through focus group discussions, key informant interviews and field observations. Binary logistic regression model and descriptive statistics were used to analyze the data. The result showed that the majority (87%) of the farmers interviewed were using SWC structures. Regionally, nearly all farmers in the low-potential areas and 56% of farmers in the high-potential areas constructed and were maintaining the structures properly. This disparity is due to the fact that in the low-potential areas there have been strong governmental involvement and technical and financial support, and hence the farmers there have a better understanding of the multiple uses of physical SWC structures than do farmers in the high-potential areas. In addition, off-farm activities and free grazing plays a substantial role. We can conclude that clear understanding of the benefits of SWC structures by farmers, active involvement and technical support from the government, and genuine participation of farmers in SWC practices were found to be main factors in the adoption of SWC measures.

1. Introduction

Soil is the media to produce crop, fodder, fiber and raw materials, among other functions (Bilotta, Grove, & Mudd, 2012). However, soil erosion has become a serious problem in many countries including Ethiopia (De Graaff et al., 2008). In Ethiopia, soil loss due to water erosion is very high. At the watershed level, it was found to be 25 Mg ha^{-1} y^{-1}(Yeshaneh, Salinas, & Blöschl, 2015) in northern Ethiopia, 91.6 Mg ha^{-1} y^{-1} in western Ethiopia (Bezuayehu & Sterk, 2010), 23.4 Mg ha^{-1} y^{-1} in central Ethiopia (Gessesse, Bewket, & Bräuning, 2014), and 19.2 Mg ha^{-1} y^{-1} in northwestern Ethiopia (Mekuriaw, 2017). Soil erosion is severe on Ethiopia's agricultural land and is affecting soil fertility and productivity – and reducing the cropland available for food production (Amdihun, Gebremariam, Rebelo, & Zeleke, 2014; Hurni et al., 2010; Brkalem Shewatatek, 2015). Soil erosion is therefore a potential threat to the national food supply.

The Ethiopian government first recognized the impact of soil erosion after the 1973–1974 famine (FAO, 2003; Haregeweyn, Berhe, Tsunekawa, Tsubo, & Tsegaye, 2012), which occurred in the highly degraded parts of the country, particularly in Tigray and Wello (Herweg & Ludi, 1999; Relief & Rehabilitation Commission, 1985). Immediately, SWC measures were identified as a top-priority intervention to reduce soil loss and improve crop yields and people's livelihoods (Relief & Rehabilitation Commission, 1985). Of note, traditional SWC measures have long been practiced in some areas of the country (Osman & Suerborn, 2001). In the 1970s, the Ethiopian government started SWC campaigns in the highly degraded highlands of the country (Haregeweyn et al., 2012; Amdihun et al., 2014; De Muelenaere et al., 2014). As part of this campaign, the country was classified into two regions: the drought-prone region also called low-potential areas (areas where the fertility of its soil and the distribution and availability of rain is suitable for rain-fed agriculture); and the non-drought prone region also called high-potential areas (areas where there is shortage

* Corresponding author.
E-mail address: asnie12@yahoo.com (A. Mekuriaw).
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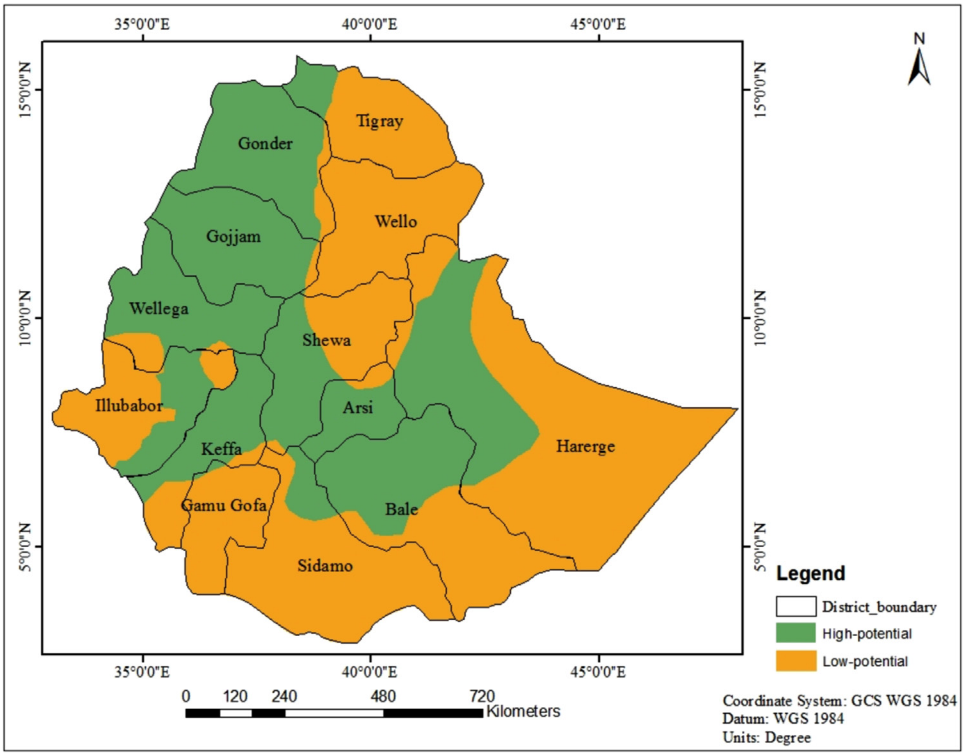

Fig. 1. Map of Ethiopia (before 1991). The areas shaded in orange indicate the districts most affected by drought (low-potential areas), while the areas shaded in green indicate the high-potential areas. Source: RRC 1985. [Note: the designated potential of each district may differ today.].

of rainfall for rain-fed agriculture) (Relief & Rehabilitation Commission, 1985) (Fig. 1). The government subsequently encouraged farmers in the low-potential areas to implement SWC measures whereas in the high-potential areas the government encouraged farmers to adopt improved inputs, such as chemical fertilizers and seeds, in order to produce more grain.

Although the government did not encourage farmers of the high potential area to practice SWC measure; some farmers have been practicing SWC measures on their cultivated lands (Mekuriaw & Hurni, 2015). In addition, implementation of SWC measures has been undertaken as part of the agricultural extension package since the 1990s, (Woldeamlak, 2002). Moreover, a participatory approach to SWC is adopted in different parts of the country (EPA, 2012; Woldeamlak, 2007). Furthermore, the government of Ethiopia instituted a national physical SWC construction campaign since 2011 that runs for two months (January and February) every year in the high potential as well as low potential areas. The campaign is aimed at mobilizing the community to construct the necessary structures following watershed conservation principles. This approach is intended to change the attitudes of the farmers and ensure that the SWC structures are sustainable and effective.

According to Rogers' Theory of Diffusion of Innovation (1983) new ideas or technologies should be diffused to the intended user. However, adopters of innovation tend to explore the new technology, and experience how effectively it would work in their areas before accepting or rejecting those technologies. Because of this the effectiveness of the introduced SWC measures and the factors determining the adoption of SWC measures are reviewed as follows.

In the low potential areas e.g., in Tigray, particularly in Enabered and May Zeg Zeg watershed, the practice of SWC measures has reduced the volume of surface run-off by 27% (Haregeweyn et al., 2012) and by 80% (Nyssen et al., 2018), respectively. Physical SWC structures constructed in Medego watershed, Tigray, over the last two decades trap high amount of soil-60 Mg ha^{-1} y^{-1} (Mekonen & Brhane, 2011). In Wello, terraces constructed on farmlands improved the soil depth and enhance soil nutrient levels (Shimeles Damene, Tamenen, & Velk, 2012), also benefitting crop yields. Various studies showed that thanks to implementation of SWC structures, average crop yields improved (Nyssen, Frankl, Zenebe, Deckers, & Poesen, 2015) and increased by 25% on sites in northern low-potential areas of Ethiopia (Mekonen & Brhane, 2011).

However, viewed at the national level, physical SWC structures have shown mixed results in terms of their effectiveness. Stone and soil bunds perform differently in low potential areas versus high-potential areas of Ethiopia (Kato, Ringler, Yesuf, & Bryan, 2011). Their benefits regarding economic returns and impacts on productivity appear to be greater in low-potential areas than in high-potential areas (Benin, 2006). In low-potential areas, most physical SWC structures show positive effects in terms of conserving fertile topsoil and improving crop yields. In certain high-potential areas, investment in physical SWC structures may not be profitable at the farm level due to the associated loss of farmland and water logging effects of SWC structures (Nyssen et al., 2004). Bezuayehu and Sterk (2010) indicated that in the high-potential areas of western Ethiopia, 80% farmers did not practice physical SWC structures due to the apparent lack of any short-term benefits.

Factors such as demographics, the institutional context, other economic activities, and agro-ecology, which may be specific to each village, can impact farmers' adoption of SWC measures. Socio-economic factors such as age and farm size (Aklilu & De Graaff, 2007), wealth category and educational level (Asrat, Belay, & Hamito, 2004; Tesfahunegn, Tamene, Vlek, & Mekonnen, 2013) and total family size (Asrat et al., 2004) have impacts on practicing SWC measures. Farmers' perceptions of soil erosion and its impact likely affect their implementation of SWC measures (Adjaye, 2008). Participatory technology development and farmers' participation in local level conservation activities were found to be important in achieving the intended objectives (Rogers, 1983, Amsalu Aklilu 2006; Kessler, 2007).

Overall, a review of the literature indicates that, since the 1970s, the Ethiopian government has undertaken a massive SWC programme to reduce soil erosion, to improve agricultural productivity and food security and to reduce poverty. However, the success of SWC measures, while great in low-potential areas remains far below the anticipated level in the previously high-potential areas. Studies conducted recently pointed out that there are sites and conditions for success and failure of SWC in the Ethiopian highlands. However, the success and failure of SWC structures and their relationship to socio-economic, infrastructural and environmental parameters has not been investigated in detail for a variety of reasons. Therefore, this study aimed to identify the main socio-economic and environmental factors (e.g. road access and topography) and political factors that determine the adoption of physical SWC structures in the cultivated lands of the highlands of Ethiopia using a socio-economic survey including field observation.

2. Methodology

2.1. Description of the study area

Ethiopia is located in the Horn of Africa and covers an area of 1.13 million km^2 (EPA, 2012). The Ethiopian land mass, which extends from 120 m below sea level to 4533 m asl, is generally categorized into the highlands (1000 m asl and above) and the lowlands (below 1000 m asl) (Hurni et al., 2010). The highland covers 47% of Ethiopia, and it generally provide good rainfall, moderate temperatures, relatively good soils, and freshwater resources. This makes them the better place or human settlement. Consequently, the highlands host 90% of Ethiopia's population and 60% of the livestock and account for more than 90% of its agriculturally suitable area (Hurni et al., 2010).

To obtain data on the Ethiopian Highlands, high-potential and low-potential areas were identified. The Tigray and Wello regions are typical areas with a low agricultural potential, whereas the Gojam district is known for its high potential (Relief & Rehabilitation Commission, 1985). Therefore, areas in Gojam, Wello, and Tigray with very high spatial resolution imagery available on Google Earth were identified. The areas were selected to observe the physical SWC measures practiced in each case study area and its surroundings using the satellite images available on Google Earth. From the areas, sixteen case study areas were selected using the following procedures:

1. First, a 10-km-radius buffer zone was delineated along the main (asphalt) road using ArcGIS10.2 to select case study areas from accessible and inaccessible areas. Places found at a distance of 10-km is considered as inaccessible and those found at 1-km is accessible. The assumption is that main roads cannot have any influence at about 10 km distance and farther.
2. Second, the buffer zone was classified into 1-km-by-20-km lateral transects.
3. Third, lateral transects were randomly selected. However, when the randomly selected lateral transect was dominated by non-cultivated land, it was replaced by a neighbouring lateral transect.
4. Fourth, the selected lateral transects were classified into grids, 1 km^2 each.
5. Fifth, a total of sixteen case study areas, eight at distances of 0 (alongside the main road) and the remaining eight at 10 km from the main road, were selected. The assumption is that sixteen case study areas are sufficient to assess the impact of accessibility on practicing SWC measures.

As in other parts of the country, the population in each case study area depends on agriculture, mainly crop production and livestock husbandry. Of these, crop production, which is limited by minimal technological inputs and is totally dependent on natural conditions, represents the lion's share.

2.2. Methods of data collection

In this study, both primary and secondary data were used. Secondary data (e.g., average land holding, major types of crops grown and history of SWC practices) were collected from each case study areas' Natural Resource Management Department. Primary data (e.g., socio-economic data, institutional support, types and effectiveness of SWC measures) was collected using both qualitative and survey research methods. The necessary socio-economic and environmental data were collected from respondents using an open ended and close ended questionnaire. Preliminary ideas and concepts for the survey were conceived from a literature review and the personal experiences of the researcher. The following questions which can produce reliable data were asked:

(a) Household characteristics such as age, sex and education status of the respondent, number of household members, and socio-economic characteristics including main sources of income, area of cultivated land, type and number of animals they do have, and type of grazing system during the wet and dry season.
(b) Implementation of and perceptions about SWC measures and its importance. E.g., for how many years do you practice SWC measures in your own cultivated land? How do you evaluate the performance of the SWC structure? What are the constraints for practicing SWC measures?
(c) Types of support that governmental and non-governmental organization offer. E.g., does the district agriculture development office support you to construct SWC measures on your own cultivated land? Are there non-governmental organizations in the vicinity that work on SWC program? What support do they offer?

The case study areas were identified on the ground using a Global Positioning System (GPS) and maps and also with the guidance of local Development Agents (DAs). At each case study area, the local DA and respective village administrator supplied a register listing all the heads of households–1851 household heads– with cultivated land within the selected area – this was done because in the highlands of Ethiopia including the study area the heads of households are considered responsible for implementing SWC measures (Mekuriaw, 2014). From the registered 1851 household heads, about 15% of the household heads were then randomly selected from the list (Table 1). Of note, 15% of the household heads from each case study area were included in the sample.

After the respondents were identified, enumerators who worked in agricultural and rural development offices and

Table 1
Total number of household heads and selected respondents by distance (km) to the main road, and from high and low potential areas.

Distance(km) from main road	Total Number of Household Heads	Number of Respondents
0	902	128
10	949	141
Total	**1851**	**269**

understood the local language were selected to conduct the questionnaire. They were given training on how to approach and fill out the questionnaire before they visited each household and interviewed the respondents in person. All informants were interviewed independently. When the selected respondent was unavailable or declined the request to participate, the interviewer went to the next household head on the list. Four focus group discussions were conducted with the community, as were discussions with the respective DAs and other experts. In each FGD, eight to ten knowledgeable participants who were purposely selected were participated. The discussions were made between one to two hours. The discussions took place in their village. Their responses were recorded by using tape recorder. During the discussion the following questions were used:

a) Implementation of and perceptions about SWC measures and its importance. E.g., for how many years do you practice SWC measures in your own cultivated land? How do you evaluate the performance of the SWC structure? What are the constraints for practicing SWC measures?
b) Types of support that governmental and non-governmental organization offer. E.g., does the district agriculture development office support you to construct SWC measures on your own cultivated land? Are there non-governmental organizations in the vicinity that work on SWC program? What support do they offer?
c) What actions should be taken to construct SWC measures and also to make it effective and sustainable?

Field observation provided another source of data (e.g. the implementation of SWC structures and its spatial coverage and effectiveness). Besides, the areas where physical SWC structures were constructed and maintained were observed on Google Earth and in the field.

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 collection. The qualitative data were analysed using codes and explanation building. The quantitative data was first entered into computer based Statistical Package for Service Solutions (SPSS) software. The data was then screened based on its type and cleaned for analysis. After this, the data was analysed using appropriate statistical procedures based on the level of measurement of the variables involved. SPSS (version 20.0) (IBM SPSS Statistics, Armonk, NY) was used to obtain descriptive statistics, frequencies, averages, cross-tabulation, and non-parametric statistics (χ^2 test). A binary logistic regression model was used to analyze the relationship between the dichotomous dependent variable and the independent variables. It enabled to determine the impact of multiple independent variables on the dependent variable. The results were presented in tabular format. The results were then analysed with respect to selected socio-economic conditions and environmental factors.

3. Results and discussions

3.1. Current status of soil and water conservation measures

The socio-economic survey results revealed that 87% of the households sampled in the Ethiopian Highlands were using physical SWC structures to keep the soil on their cultivated land and to improve crop yields (Table 2). Regionally, it was observed that in the sampled low-potential areas, all cultivated lands that required interventions have been terraced, which was not the case in the high-potential areas. Similarly, the socio-economic survey showed that in Tigray and Wello (low-potential areas), 94% of the interviewed farmers had built and were maintaining SWC structures to keep the soil on their cultivated land and to improve productivity. Households consider the physical SWC structures to be necessary for survival. 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. This indicates that the SWC structures are able to improve ecosystem services in the low-potential areas. Various studies conducted in the low-potential areas indicated that the physical SWC structures have benefited productivity and ecosystem services (Kato et al., 2011; Lanckriet et al., 2014; Wolka, 2014).

Table 2
SWC measures practices in the highlands of Ethiopia.

Did you practice SWC structure in your cultivated land	Respondents who practice SWC measures (%)		
	Ethiopian Highland	High potential area	Low potential area
Yes	87	56	94
No	13	27	6

High-potential (n = 94) and low-potential (n = 175) areas in the Ethiopian Highlands; the sum of low- and high-potential areas (n = 269).

An elderly person from Wello (low-potential area) made the following statement: "Previously (30 years ago), soil erosion was the most serious problem in our area. Although we had a large area of cultivated land, we did not produce sufficient grain to feed our family. Cognizant of the problem, the then government of Ethiopia introduced the idea of SWC measures even if we (some people) had practiced it even before. Since we were seeking a solution, we did not oppose the idea of the government, and thus we have constructed the necessary SWC structures. Finally, we are able to keep the soil on our cultivated land and start to produce good yields. Now we know that the solution is in our hands. However, at present there is one serious problem – change in rainfall amount, and pattern, which is beyond our control. Instead, it is controlled by only one super power, GOD."

In the sampled high-potential area, 56% of the interviewed farmers had built SWC structures on cultivated land. Like farmers in the low-potential areas, they acknowledged that soil erosion damages cultivated and grazing lands and consequently affects crop yield and livestock production. Kaspar et al. (2015) reported that the annual soil loss rate in Ethiopia is about 852.8 million Mg ha^{-1} y^{-1} on the whole land use type. Moreover, during a field visit to the high-potential areas, soil erosion and gully formation were observed on cultivated and grazing lands (Fig. 2). If this trend continues and if physical SWC structures are not constructed and maintained, soil erosion will worsen, significantly affecting crop yield and food security. However, many of the households sampled (44%) have not built physical SWC structures. Farmers involved in a focus group discussion reported that most farmers had totally or partially removed the structures. Consequently, at present the land is degraded and thus suitable only for certain crop types, which was not the case some years ago. Although farmers in the Ethiopian Highlands understand the history and extent of the soil erosion problem (Table 3), substantial differences in adoption of SWC structures were found between the high-potential and low-potential areas (Table 2). The factors determining the adoption of SWC measures are discussed below.

(a) (b)

Fig. 2. Photographs showing the impact of soil erosion (a) on farmland (Asnake Mekuriaw, November 2011) and (b) on grazing land in Gojam (Mekuriaw, 2012). This is a common problem in the high-potential areas.

Table 3
Farmers' perceptions of the most serious environmental problems.

Environmental Problem	Percentage of Respondents		
	Ethiopian Highlands	High-Potential Areas	Low-Potential Areas
Rainfall change[a]	61	6	90
Soil erosion	30	84	1
Deforestation	5	9	3
Water scarcity	4	1	6
Total	**100**	**100**	**100**

High-potential ($n = 94$) and low-potential ($n = 175$) areas in the Ethiopian Highlands; the sum of low- and high-potential areas ($n = 269$).

[a] Rainfall change indicates both unexpected rainfall and shortage of rainfall during the rainy season.

3.2. *Attitude of farmers on the importance of soil and water conservation structures*

The result showed that in the sampled low-potential areas, nearly all farmers have maintained SWC structures (Table 2). Despite the fact that cultivated land holdings are small (less than 1 ha) and almost equal to the farm size in the low-potential areas, many farmers of the high-potential areas have not built and maintained physical SWC structures because (1) they do not perceive a significant advantage to their use; instead, they see that SWC structures reduce crop yields by narrowing already limited cultivable lands, and (2) lack of short-term economic benefit. It is clear that the land on which the structure is installed is not used for crop production, however, it reduces soil erosion and keeps the soil in place. Alufah, Shisanya, and Obando (2012) indicated that farmers' implementation (or rejection) of SWC structures is significantly affected by their perceptions of soil erosion and its impact. But farmers are looking for immediate benefits rather than focusing on the long-term positive effects from SWC structures. Similarly, Bezuayehu and Sterk (2010) and Amdihun et al. (2014) reported that many of the high-potential area farmers are not willing to implement SWC measures if they do not get short-term economic benefit (Amdihun et al., 2014; Bezuayehu & Sterk, 2010).

In the high-potential areas the constructed physical SWC structures improved the productivity of the land after seven years (Schmidt & Tadesse, 2012) but Bezuayehu and Sterk (2010) argued that in high-potential areas, physical SWC structures did not have significant impacts on productivity of the land. However, in the long run, physical SWC structures can reduce soil loss and keep the soil in place and improve soil fertility and crop yield and it can regulate and maintain stream and river flows. Similarly, Hurni, Tato, and Zeleke (2005) found a positive relationship between SWC structures used upstream and better river flow downstream. Awareness on the multiple uses of SWC structures were found to be main factors in the adoption of SWC measures

3.3. *Socio-economic factors*

The main characteristics of the respondents – including sex of household head, age, level of education, labour, landholding, off-farm activity and number of livestock – were investigated to understand their influence on the adoption of SWC measures. Socio-economic factors such as age, education, number of employable family members, landholding, and sex of household head did not have a significant impact on adoption and maintenance of SWC structures in this study (Table 4). The research regarding the effect of age on conservation practices is contradictory, as Tesfahunegn et al. (2013) and Wolka and Negash (2014) observed that it had negative effect on the practice of SWC measures, whereas Aklilu and De Graaff (2007) and Brkalem Shewatatek (2015) found that age has a positive impact on practicing SWC measures - older farmers are better at constructing and maintaining SWC structures than their young counterparts. Further, researchers revealed that farmers who maintain larger farms are more likely to apply SWC measures than those whose farms are relatively small (Aklilu & De Graaff, 2007; Wolka & Negash, 2014), perhaps those with more

Table 4
Binary logistic regression model results for factors influencing the adoption of soil and water conservation practices ($n = 269$).

Explanatory variable	(p-value)
Age	0.308^{ns}
Education	0.251^{ns}
Labour	0.577^{ns}
Landholding	0.670^{ns}
Off-farm activities (selling firewood)	0.001^{*}
Sex of household head	0.661^{ns}
TLU	0.194^{ns}
Use of free grazing systems (communal land)	0.001^{*}

* Shows significance at $p \leq 0.001$. ns Non-significance.

Table 5
Farmers' use of soil and water conservation structures (n = 269).

Response	Percentage of Respondents		
	Distance From the Main Road		
	0 km (n = 128)	10 km (n = 141)	χ^2 (p-value)
Do you use SWC structures?			
Yes	84	89	1.059 (0.303)^{ns}
No	16	11	

* Shows significance at p ≤ 0.001. ^{ns} Non-significance.

land are less concerned about making room for the SWC structures. Education level of the household head did not have a significant impact on adoption and maintenance of SWC structures whereas family size did have positive impact on it (Wolka & Negash, 2014).

Among household characteristics, off-farm activities (selling firewood) and use of free grazing systems (communal land) influenced the adoption of introduced SWC practices negatively and it was statistically significant. Farmers who practiced off-farm activities such as pretty trade and selling of firewood were not maintaining SWC structures because off-farm activities that occur in the dry season, when bunds are constructed and maintained, compete with the labour force with soil conservation practices. Similarly, Berhanu Gebremedhin and Swinton (2003) found that off-farm activities substantially affect SWC practices.

3.4. Physical factors

This study showed that 89% of the farmers interviewed in inaccessible areas were practicing and maintaining SWC structures, whereas the remaining 11% were not (Table 5). In the accessible areas, 84% of the respondents were practicing and maintaining SWC structures. The statistical analysis showed no significant difference between farmers in accessible and inaccessible areas regarding the use of SWC structures ($p \geq 0.303$). Similarly, physical factors such as topography and slope of farm land did not emerge as important factors, according to the respondents and based on observation (at the field and on Google Earth).

3.5. Free grazing

This study shows that 93% and 81% of the respondents in the high-potential and low-potential areas, respectively owned oxen and cows (Table 6). Some also owned donkeys, sheep and goats, mules, horses and camels. On average, farmers in high-potential areas owned more livestock (5 TLU) than farmers in low-potential areas (4 TLU). Livestock provides various benefits to households, including food, income, manure, labour, transport, breeding, and even prestige. Farmers also use livestock as a bank for saving money and as insurance for the security of the household. Concerning cattle feed, the principal sources were straw, free grazing (on cultivated and communal grass land), private grasslands, and crop residues (Table 7). Farmers in the high-potential areas used the free grazing system, while those in the low-potential areas were using the cut-and-carry system and straw. In high-potential areas where free grazing systems are available, the plots are overgrazed. Overgrazing adversely affect grass species (Angassa, 2014), and thus cattle must travel long distances to get sufficient food. When cattle travel or graze on the terraced fields, their treads put increased pressure on the structures. Consequently, the animals often damage and/or demolish them (particularly the newly constructed bunds). Because of this, the interviewed high potential area farmers have not given much attention to the construction and maintenance of physical SWC structures.

3.6. Land tenure

In Ethiopia land is owned by the state and farmers have use right. The tenure system is identical in both high- and low-potential areas. Realizing the need for securing land tenure for sustainable land management, the current government of the country has halted further land redistribution and has started land certification for farmers since 2005, which protects use rights as long as farmers wisely use their land. All farmers participated in a focus group discussion indicated that they feel their land use right is secured because of land certification. Therefore, this factor was not influencing the adoption of SWC measures.

3.7. Political factors

Since the 1970s, the government of Ethiopia has given priority to the low-potential areas, which have thus been able to construct and maintain soil conservation structures. For example, the government's financial contributions to SWC activities on cultivated lands in the Tigray, Amhara, and Oromia regions from 2000 to 2004 were identical (FAO, 2003) even though the three regions differ in terms of total area covered and total population. For example, the Amhara region is three times as large as the Tigray region; and the Oromia region is a bit larger than the Amhara region. The government did this for their own reason. Whatever the reason, the earmarked budgetary funds were to be used for capacity building, development and dissemination of SWC measures, and awareness raising at the grassroots level (FAO, 2003), which is the foundation for adoption and success of the SWC programme. Moreover, the government has encouraged NGOs to work in the low-potential areas. For example, Nyssen (1998) reported that farmers in the low-potential areas (e.g., Tigray) were mobilized and supported by local and international NGOs in applying physical SWC practices. The implication is that in the low-potential areas, NGOs and multilateral organizations delivered the

Table 6
Number of cattle owned by the respondents in the sampled highlands of Ethiopia.

Cattle type	High potential area		Low potential area	
	Number of cattle	%of respondents who have cattle	Number of cattle	%of respondents who have cattle
Ox and cow	286	93	382	81
Heifer and bull	106	64	109	42
Calf	71	57	106	46
Sheep and goat	150	49	173	33
Kid and lump	40	21	97	23
Donkey	87	54	101	41

High-potential (n = 94) and low-potential (n = 175) areas in the Ethiopian Highlands.

Table 7
Sources of cattle fodder in the sampled highlands of Ethiopia.

Grazing system	Percentage of Respondents			
	High potential area		Low potential area	
	Dry season	Wet season	Dry season	Wet season
Free grazing	98	96	7	32
Private grasslands	52	53	5	41
Straw	98	98	100	91
Cut and carry	0	5	0	91

The percentage of respondents exceeds 100% because of multiple responses.

necessary equipment and trained farmers and their respective DAs on how to construct and maintain SWC structures to improve their livelihood, which was not the case in high-potential areas. Consequently, SWC measures have effectively been implemented in the low-potential areas (e.g., Tigray) since the 1991 (Lanckriet et al., 2014; Asnake Mekuriaw & Hans Hurni, 2015).

In the high- potential areas, farmers involved in the focus group discussions indicated that lack of awareness and strict enforcement and limited access to knowledge and lack of technical support were the main reasons for the low adoption and performance. Even though governmental bodies declared that they were following a bottom-up approach, the reality was the reverse, according to the farmers and researchers (e.g. Amdihun et al., 2014). Ignoring farmer's knowledge of local problems and their input in practicing SWC measures could be another reason for the failure of SWC programs. The implementation and success of SWC structures are constrained by application of top-down approaches, insufficient institutional support, and general failures to enable farmers genuine participation in key SWC activities (Bezuayehu & Sterk, 2010).

Generally, the Ethiopian government has strongly supported the low-potential farmers technically and financially since the mid-1970s. Furthermore, the government has encouraged NGOs to work in and support the low potential areas. Consequently, all cultivated lands in the sample that required physical SWC structures had been terraced, which was not the case in the high-potential areas. Therefore, strong governmental support and follow up substantially influence the adoption of SWC measures.

4. Conclusions

In the study area, the majority of farmers had constructed and was maintaining physical SWC structures on their cultivated lands. In the low-potential areas of the country (particularly in Wello and Tigray), where the government has emphasized SWC structures, nearly all farmlands in the sample that required physical SWC structures had been terraced and were thus able to minimize the rate of soil erosion and improved ecosystem services. However, in the high-potential areas, where the emphasis was low, the achievements of physical SWC structures were below the anticipated levels. We found that lack of awareness of physical SWC structures' possible long-term benefits, low short-term economic benefits of SWC structures, and political factors (e.g. lack of strong governmental involvement and technical support) and off-farm activities such as petty trade and selling of firewood are the key factors significantly determine farmers' use of SWC structures. However, accessibility to the main road did not have significant impacts on the construction and maintenance of SWC structures. Therefore, a change in farmers' attitudes about SWC measures and their role in halting soil erosion and related impacts are important in order to encourage the construction and maintenance of these structures.

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