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Agro-pastorals' adoption of soil and water conservation (SWC) technologies: The case of Aba'ala district in Afar Region, Ethiopia

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This study assessed agro-pastoralists' adoption of soil and water conservation measures in Aba'alla. A convergent parallel mixed design was used, combining quantitative and qualitative methods. Samples were taken from five selected kebelles of spate irrigation areas in the Woreda. Questionnaires, group discussions, interviews and field observations were used. About 150 households were taken from 2450 households using simple random sampling techniques for administration of the questionnaires. To examine perception of the agro-pastoralists, a five-point Likert rating scale was employed. Moreover, bi-variate and multi-variate statistical analyses were applied. The results showed that adoption of soil and water conservation technologies of agro-pastoralists is significantly and positively correlated with their perception level on soil erosion (r=.308, p<0.01) and its effect (r=.182, p<0.05). Their perception, related with household head's perception on soil erosion, is positively and significantly correlated with his/her educational status and other factors. The results showed that 35.3, 28.7, 17.3 and 8.7% of sample households are respectively: very low adoption, low adoption, moderate adoption, high adoption; and the remainder are non-adopters. They reported using structural like gabions and bunds and sometimes agronomic methods. Only a few farmers used biological soil conservation methods. Among these methods, soil management methods contour farming and minimum tillage are relatively in wider usage. Factors negatively affecting the farmers' adoption of SWC included gender, age, marital status, number of children, size of farm, credit and land ownership. However, educational attainment of household, off-farm activity, extension, participation on mass SWC campaign, perceived erosion occurrence, livestock wealth and farming experience are positively affecting it. From these factors, statistically significant ones are educational status (at p<0.01), access to extension (at p<0.01) and credit (at p<0.05), off-farm activity (at p<0.05), and land tenancy (at p<0.05), those factors significantly affecting the adoption extent and behavior of agro-pastoral community of the study area.

Key words: Adoption of conservation practices, conservation failures and preferences, demographic factors, flooding, soil and water conservation (SWC) measures.

INTRODUCTION

Land degradation has caused a series of environmental problems for a long period of time throughout the world, because it damages and reduces soil fertility. It has been the causes for soil fertility reduction, food insecurity, depletion of productive resource, influenced individual production capacity, and led to agricultural land deterioration, and decreases in its production (Masebo et al., 2014).

Land degradation is also one of the basic problems the farmers have been facing, which hindered agricultural production and caused food insecurity in Ethiopia (Mengstie, 2009). Although estimates of the extent and rate of soil erosion lack consistency, the results of various studies highlighted the severity of the problem. According to Wood (1990), Kruger et al. (1996) showed that 3.7% (2 million ha) of Ethiopian highlands had been seriously eroded. As Woldeamlak and Sterk (2003) and Bobe (2004), investigated in Ethiopia: about 27 million ha are significantly eroded; 14 million ha are seriously eroded and 2 million ha reached the point of no return with an estimated total loss of about 2 billion meter cube soil per year.

In Ethiopia in general, factors affecting adoption and continued use of soil and water conservation measures are assumed to be less studied (Wogayehu, 2005). The achievement of soil and water conservation measures is below the expectation and the country loses a tremendous amount of fertile topsoil, and threat of soil degradation is alarmingly broadening (Teklu and Gezahegn, 2003).

As a response to the problem, the country initiated urgent intervention strategies through the program of Land Resource Management; which includes soil and water conservation (SWC), sustainable soil and water conservation, and forest resource conservation. Land resource management has received special attention in recent years, particularly for use of integrated Soil and Water Conservation strategies. These strategies were classified as: Structural (mechanical) measures and Agronomic measures/Vegetative measures (Mekuria 2005; Mitiku et al., 2006).

The success and sustainability of soil conservation intervention depends on clear understanding of causes and extent of soil degradation, implementation of appropriate soil and water conservation technologies and involvement of farmers on designing and implementation, and factors that favor adoption and use of soil and water conservation technology (Kessler, 2006).

In this regard, only a few studies have been conducted in the country (Belay, 1992; Yeraswork, 2000; Atakiltie, 2003; Wogayehu and Lars, 2003; Woldeamlak and Sterk, 2003; Amsalu and Graaff, 2007; Atnafe et al., 2015). They were conducted in different parts of the country (most of them were confined to the northern part of Ethiopia) but no study has been conducted in the study area regarding this. Most of them emphasized such topics as identification of types of soil and water conservation technologies, limited factors affecting adoption of soil and water conservation technologies (Morgan, 2005).

Several interventions and programs were made in SWC and several areas have been covered with Structural SWCTs (Tesfaye, 2008). However, the SWC technologies are low because of the approaches and adoption behaviors of the farmers to transfer and development of SWCM (Shiferaw and Holden, 1999, Teklu and Gezahegn, 2003, Amsalu and Graaff, 2007). The effectiveness of LRM Efforts made and SWCTs used were also below expected due to less emphasis given for factors affecting adoption and use of Soil and Water Conservation measures, less consideration of farmer's attitudes, perception and needs towards SWCMs, and the expansion of SWCMs was without sufficient knowledge of farmer's adoption behavior among others (Wogayehu, 2005).

In Aba'ala, since the 1990s, different soil and water conservation technologies were introduced in agricultural development intervention programs, which involved the mass mobilization of the peasant association with its huge labor force. However, only a few of them were effective and productive due to the following issues: continuous soil erosion, damage of public properties in soil erosion, low agricultural productivity, and profitability of introduced SWCM (Solomon and Abebe, 2012).

The diversion of flood water into the arable lands has enabled agro-pastoralists to produce late maturing crops. This practice plays a key role in alleviating the existing moisture stress problems. However, this traditional flood diversion practice is labor intensive, requires frequent maintenance and usually the flood resources are underutilized as the agro-pastoralists divert (Ibid).

Adoption of simple and cheap technologies for flood diversion structures (gabions) rather than using traditional practices are preferable and adapted to the local soil and weather situations (Solomon and Abebe, 2012). This all implies that development and transfer of LRM technologies need multiple approaches, and profitable LRMPs, alternative strategies to develop and transfer the technologies, and adoption and use of SWC measures in an integrated manner.

Objectives of the study

General objective

The general objective of the study was to assess the agro-pastorals' adoption of soil and water conservation

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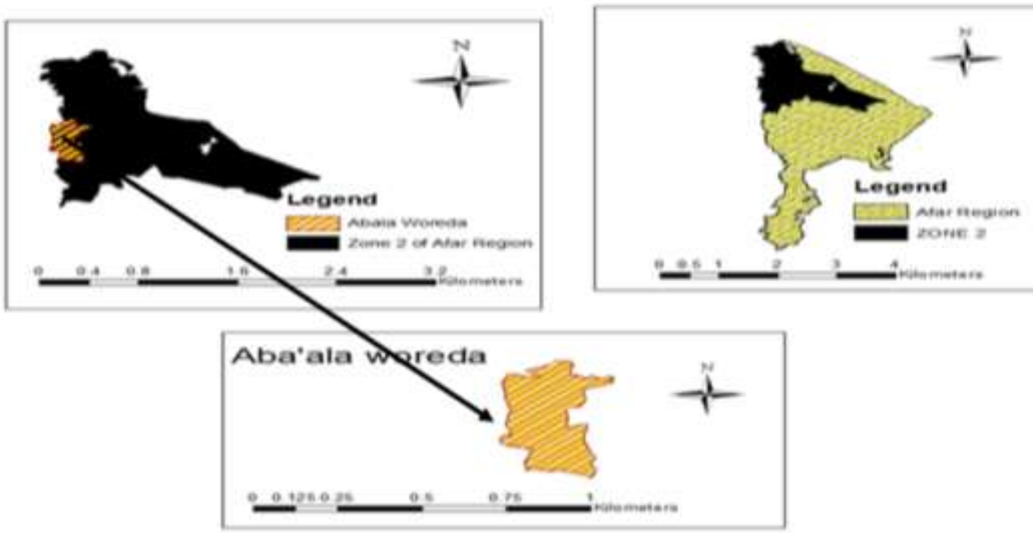

Figure 1. Locational map of the area.

technologies in Aba'ala district**.**

Specific objectives

The specific objectives of the study are:

(1) Examining the perception of agro-pastoralists' opinions on soil erosion and its causes and effects.
(2) Assessing soil and water conservation technologies being used in the study area.
(3) Identifying and describing the extent of soil and water conservation measures that are used, failures and preferences by the agro-pastoralists.
(4) Identifying the factors that affect agro-pastoralists' decisions on use of SWC strategies.

METHODOLOGY

General description of the study area

Physical, socio- economic and demographic characteristics of the study area

Aba'ala is located in the Afar regional state. Geographically, it is located at 13°22′N 39°45′E coordinates. It is one of the Woreda's in the Afar Regional state of Ethiopia in zone 2 administration. It is located at the base of the eastern escarpment of the Ethiopian highlands, and bordered on the south by Megale, in the west by the Tigray Region, in the north by Berhale, in the northeast by Afdera, and in the east by Erebti. The woreda has 11 administrative kebelles (Figure 1).

Aba'ala has an aerial coverage of 1700 km^2 and from this one third is floodplain, with the remaining area being higher, hilly, and mountainous. May-Shugala and May Aba'ala are the main perennial rivers that supply water to the area. Murga and Liena are also large seasonal rivers found in the area (Solomon and Abebe, 2012). The area is a semi-arid type of climate and receiving bimodal rainfall patterns. The long rains usually occur from mid-June to mid-September, while the short rains usually come in March and April. Mean annual rainfall varies between 150 and 500 mm and the amount and reliability declines from west to east (Diress et al., 1998; Net Consult P.L.C., 2005). The rainfall intensity is usually high leading to short lived high runoff volume, and this coupled with a high evaporation rate makes the rainfall insufficient for crop production. Therefore, the agro-pastoralists in the Woreda in general, and at the Aba'ala plain in particular, depend highly on the flood water coming from the highlands of the Tigray region to produce crops (Ibid).

Generally, the area is hot with high diurnal temperature, and experiences severe heat during the dry period (May to June) with the maximum of 33 ^{0}C; and a minimum of 11.6 ^{0}C temperatures typically in June and November (Net Consult PLC, 2005). The three main land use types found in Aba'ala are cultivation, grazing and settlement. The plain is covered by woody bush dominated with many trees and shrubs (Diress et al., 1998). Subsistence crops are common, but cash crops, including cotton, oilseeds and in some areas vegetables, are also grown (Solomon and Abebe, 2012).

Currently, the economy of the Aba'ala plain people is predominantly agro-pastoralism, whereby both livestock and crop production are practiced jointly (Solomon and Abebe, 2012). Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Woreda has a total population of 37,963, of whom 20,486 are men and 17,477 women.

Research design/approach

In this study, a convergent parallel mixed design was applied as Tashakkori and Teddlie (1998) illustrate, which has been effective for the last 20 years. A mixed research design is a procedure for collecting, analyzing, and interpretation of both quantitative and qualitative data in a single study to investigate a research problem

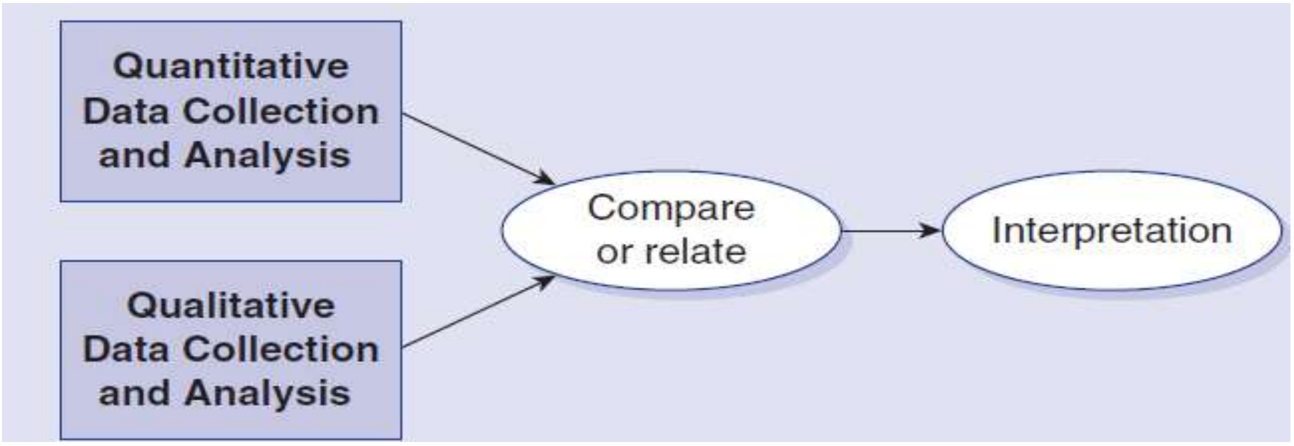

Figure 2. Convergent parallel mixed design.
Source: http://www.fischlerschool.nova.edu/appliedresearch/procedures_and_resources.

(Figure 2).

Data sources and method of data collection

Primary data was collected from land user, rural development agents, Woreda soil and water conservation experts and kebelle leaders. Secondary data was obtained from the reports, books, journals, and documents from offices of Agricultural Development and Water Resources, Land and Environmental Protection at Zonal, Woreda and kebelle level.

An important method of primary data collection for this study was critical field observation, structured interviews, formal group discussions, and a questionnaire. The questionnaire was first pre-tested and some modifications were made, before the administration of the formal survey.

Sample size and sampling techniques

The study area was selected by purposive sampling, because it is seriously affected by soil erosion in Afar Region and represents a locality where there is different soil and water conservation efforts that are carried out. From 11 kebelles in the Woreda, five lowland/plain kebelles of spate irrigation area was purposively selected as sample kebelles. The total household heads who engaged in the agricultural activities are estimated after each kebelle population is assessed by the following formula. The required sample size was determined using a simplified formula provided by Yamane (1967), as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where 'n' is number of representative samples to be taken for the study, 'N' is total population from which samples will be taken and 'e' is the error to be considered i.e. level of precision (9%).

If the population is small then the sample size can be reduced slightly. The sample size (n_0) can thus be adjusted using the corrected formulae:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

Where n is the sample size, N is the population size and n_o is calculated sample size for infinite population.

This formula was applied for the total households of the five kebelles, and by its use the total samples were determined. Totally, about 150 households were taken from 2450 households of the area (Table 1). The households in the sample kebelles were taken by simple random sampling techniques as shown in Figure 3.

Methods of data analysis and interpretation

Both qualitative and quantitative data analysis and interpretation were carried out. Qualitative primary data was analyzed by using qualitative techniques (verbal description). First, it was collected, identified, organized and compiled into a short form and categorized into different themes and finally discussed. Quantitative primary data were categorized, classified, tabulated, coded and entered into a computer for analysis. For analysis, SPSS v. 20 was employed. In this case frequency and descriptive statistical analysis has been carried out through cross tabulation whereby percentages, means, medians and standard deviations were computed. To examine perception of agro-pastoralists, five-point Likert rating scales were employed. Moreover, bi-variate and multi-variate statistical analysis has been done. The uni-variate analysis provides simply descriptive statistics of key factors that influence adoption of soil and water conservation methods. In the bi-variate analysis, correlations were employed to test the association between the dependent and the independent variables. The multivariate analysis simultaneously examines the impact of many variables on probability to adopt soil and water conservation methods. In this regard, multinomial logistic models were employed to analyze the overall influence of independent variables on dependent variables. Hosmer and Lemeshow (1989) have pointed out that the logistic distribution has an advantage over the others in the analysis of a dichotomous dependent variable. It is extremely flexible, relatively simple from mathematical point of view and lends itself to a

Table 1. Statistics of five selected Kebelle administrations.

Name	Livelihood	N	n	n_o
Arkudi	Agro-pastoral	451	96.7	25
Hidmo	Agro-pastoral	348	91	23
Wakrigubi (town)	Agro-pastoral	498	99.6	30
Adi-haremele	Agro-pastoral	621	103.5	42
Assengola	Agro-pastoral	532	103.3	32
Total	2450	-	-	150

Source: Central Statistics Agency Report (2008).
Note: N = total number of household heads, n = number of sample households.

meaningful interpretation by using both *t* and *f-test*.

RESULTS AND DISCUSSION

Demographic and socio-economic analysis

Age-gender characteristics

From the sampled households, 85.3% were male-headed households and 14.7% were female- headed households. Females were family-headed when their husband was no longer present due to divorce, died, or migrated from their original residences, and for other related reasons. The interview showed us, most of the females who are household heads manage their land through share cropping or renting to families with male household heads and contract with other men from Tigray highland to plough. As shown in Figure 4, about 46.26% of the population was in the 36 to 50 age level, and was followed by 36.73% of household heads in the 18 to 35 age level. This indicates that a large number of household heads are in the medium and younger age groups. However, the other 17% of respondents lie in the age of 51 to 64 and above. These farmers, especially the elderly age groups, usually implemented and accepted soil and water conservation practices, because they have access to money for rented oxen as well as hired labor provided by the younger age group. However, the proportion of elderly people and young farmers was an age group in which labor shortage can be a hindrance to practicing soil-water conservation measures (Addisu, 2011).

Household size

The number of children in each family is shown in Figure 5. By its nature, soil and water conservation structure is labor intensive; and households with larger household size make a decision to retain structures. However, families with only a large household size fail to make decision to maintain and retain conservation structures. In most Ethiopian rural areas, the main sources of labor are the family members, including wife and children (Shiferaw et al., 2007). As shown in Figure 5, 51.33, 34.67% and 14% percent of the sample household have more than 5 children, 3-4 children and 1-2 children, respectively. The area has an advantage to adopt SWC technologies. Similarly, the finding of Habtamu (2006) in Hadiya zone on adoption of physical soil and water conservation structure supports this conclusion.

Educational status

The educational status of the respondents is presented in Table 2. The study has identified four educational levels in the study district:

(1) Illiterate
(2) Can read and write/primary education
(3) Secondary schooling, and
(4) Further education (diploma and above).

From Table 2 it is apparent that 46% of the household heads had no formal education and/or illiterate, 35.3% of the respondents had a primary education, 10.7% completed secondary schooling, and only 8.0 % pursued further education. Most of the farmer household heads in the study area were not educated; because of this, they have little information about newly introduced SWC practices. Similarly, in the finding of *Koga* watershed (highlands of Ethiopia), and *Goromti* watershed, as shown by Mengstie (2009) and Addisu (2011) educated households have more informed perceptions about soil erosion problems, SWC, and conservation activities.

Land holding and tenancy

Land distribution in the Woreda was undertaken 40 years ago during the reign of Emperor Haileselassie and since then no land distribution has been undertaken. The Afar and Tigrian agro-pastoralists are the owners of the cultivated land (Solomon and Abebe, 2012).

The result as shown in Table 3 is 67.3% have below 1 ha, 25.3% have 1 to 5 ha, and the remaining 4% have 6 to 10 ha. Similarly, more soil and water conservation practices were practiced on larger plots as the farmers have more flexibility in their decision making, greater access to discretionary resources, more opportunity to use new practice of SWC structures and have more ability to deal with the risk that takes place on their farm land.

Similarly according to Habtamu (2014), as land is further fragmented, it becomes uneconomical in size and

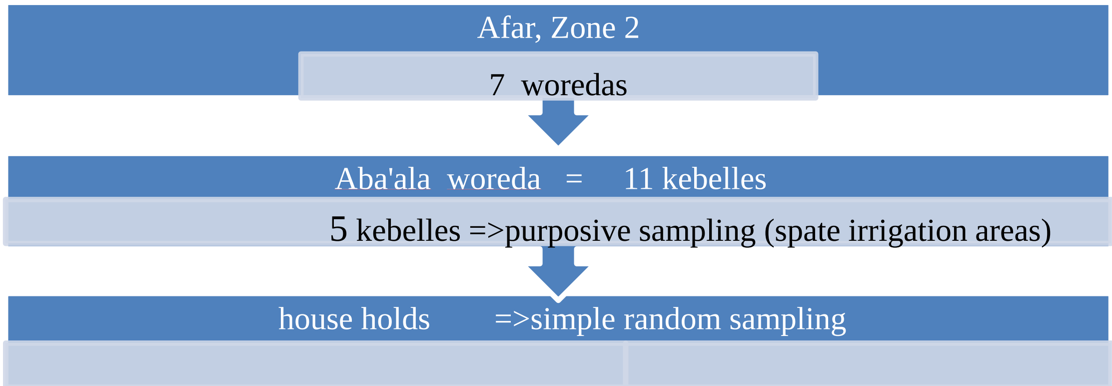

Figure 3. Sampling plan.

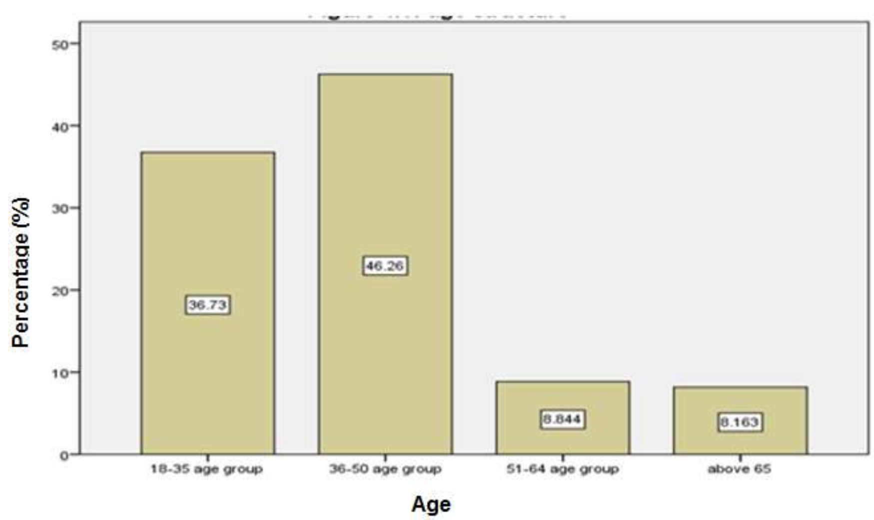

Figure 4. Age structure of respondents.

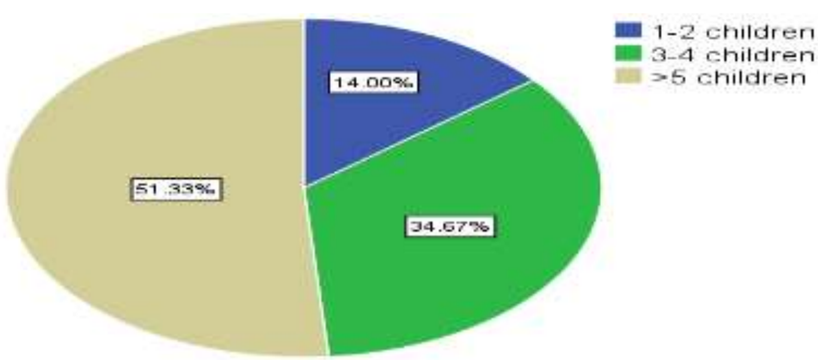

Figure 5. Number of children in a family.

left with little room for implementing structural soil and water conservation measures. Land size and practice of structural soil conservation measures have a strong positive relationship. The small farm-size holders may

Table 2. Educational status of respondents.

Education category	Frequency	Percentage
Illiterate	69	46.0
Primary education	53	35.3
Secondary education	16	10.7
Further education	12	8.0
Total	150	100.0

Source:-Field survey (2016).

Table 3. Farm land size of household.

Land size in hectare		Frequency	Percentage
Valid	Below one ha	101	67.3
	1 up to 5 ha	38	25.3
	6 up to 10 ha	6	4.0
	Total	145	96.7
Missing	-	5	3.3
Total		150	100.0

Source: Field survey (2016).

have negative attitudes towards structural soil and water conservation measures. These farmers lack trust on structural soil-water conservation measures as they only participated poorly in the planning and designing of the soil and water conservation program. Hence, farmers fear loss of land during the construction of soil bunds, terraces, and check dams.

On the other hand, in Aba'ala many farmers operate a land received on a *sharecropping* basis and *renting* of land, as interview evidence from focus group discussions with farmers show. Sharecropping is on an *in and out* arrangement. As interviewed farmers reflected in their narrative, many of crop growers are on sharecropping out basis. This highly affected their behavior of adoption of soil and water conservation technologies. The survey result of this study also showed that 96 (64%) farmers among 150 respondents own their land, while 54 (36%) do not have their own farmland.

Land characteristics

In the results obtained on soil characteristics (Table 4), about 88% of respondents stated that their soil is low in fertility, and the remaining ones report that they have infertile soil for any agricultural activities. Whereas 41.3% of the respondents said their soil fertility is medium; the others (24.0%) and 22.7% reported that their soil is low and high in its fertility. On the other hand, 70.7% of surveyed soil is on a level topography (gentle slope) and the remaining 29.3% soil is on sloppy land. As observation results show, most of these sloppy lands are toward the highland and escarpments of Tigray highlands. The study done by Demeke (2003) showed that the practice of constructing bunds on plots that is flat and not susceptible to erosion is criticized by farmers, because they may suspect that it can result in a water logging problem on the field, which is similar to findings in this study.

Access to extension service

As shown in Demeke (2003), it is a recognized fact that the diffusion of information on improved technological alternatives is an important element that contributes positively for the adoption and sustained use of a given technology. Unless there is an adequate mechanism for transmitting information, the adoption of any new agricultural practice would not be successful. Lack of relevant and timely information can prevent a widespread adoption of new technologies. In the study area, unlike the others, the widely used means of disseminating information through public extension service is very low. Similarly, in the findings of the research study reported here, about 68% of farmers did not get this service; while the remaining 32% did. There is also a positive and significant correlation between access to extension service and adoption of the technologies ($p < 0.01$).

Economy and wealth

Table 5 indicates that most of surveyed household (86%) engage in both crop production and livestock ranching, and 10% depend only on crop production. The results of the field survey and interview indicate that keeping livestock is an important component of the farming system in the study area. A vast majority of the sample households included in this survey own dominantly camels, cattle, sheep or goats and a few donkeys. The size of livestock owned indicates the wealth status of the household in the study area (in long Afar culture). A large number of sample households (98 of 145) own 1-20 livestock and 31 of 145 households own 21 to 60 of livestock, and only 6 household from among 145 own more than 60 livestock in TLU; while the other 10 respondent do not have livestock. This is also reported by Solomon and Abebe (2012), as livestock production is an important livelihood for agro-pastoralists and pastoralist communities.

In addition, about 32% of the farmers in the study area have engaged in off-farm activities. As the survey results show, most of these farmers are governmental and NGO workers and some private business workers. As it was depicted in Table 5, most of the farmers (72.0%) have no

Table 4. Soil fertility.

Land fertility level		Frequency	Valid percentage (%)	Cumulative percentage
Valid	High	34	22.7	22.7
	Medium	62	41.3	64.0
	Low	36	24.0	88.0
	Infertile	18	12.0	100.0
	Total	150	100.0	-

Source: Field survey (2016).

Table 5. Economic status of respondents.

Items	Category		Frequency	Percentage
Livelihood	Valid	Crop production	15	10.0
		Mixed farming	129	86.0
		Total	144	96.0
	Missing	77.00	6	4.0
	Total		150	100.0
Livestock in TLU	Valid	No livestock	10	8.0
		1-20 livestock	98	64.0
		21-40 livestock	31	20.7
	Missing	61-100 livestock	6	4.0
		Total	145	96.7
	Total		150	100.0
Off-farm employment	Valid	No off-farm employment	102	68.0
		Have off-farm employment	48	32.0
		Total	150	100.0
Access to credit	Valid	Enough access	0	0.0
		Somewhat enough access	5	1.3
		Not enough access	33	22.0
		No access at all	109	72.7
		Total	144	96.0
	Missing	77.00	6	4.0
	Total		150	100.0

Source: Field survey (2016).

access to credit at all, 22.0 % have access but not enough and few of them (1.3%) have somewhat enough access to credit. This generally indicated to us that the farmers in the study area have no, or very little, access to credit; which can be one of the factors that led to very little investment in soil and water conservation technologies. Similarly according to the finding of Solomon and Abebe (2012), rural households in developing countries lack adequate access to credit. This in turn impinges a significant negative impact on technology adoption, agricultural productivity, nutrition, health, and overall household welfare (Diagne and Zeller, 2001; Wogayehu and Lars, 2003).

Agro-Pastoralists' perception of soil erosion

Understanding farmers' perception of soil erosion and its impact is important in promoting soil and water conservation technologies (Chizana et al., 2006). Soil erosion is an insidious and slow process therefore farmers need to perceive its severity and the associated yield loss before they can consider implementing soil and water conservation practices (Table 6). Data in Table 6 depicted that the adopting and not adopting probability of the agro-pastoralists was significantly related with their knowledge on erosion ($r = 0.196$, $p < 0.05$). The adoption probability increases with the increasing perception level

Table 6. Perception of agro-pastoral community on soil erosion.

Variable		ADOPT	ADOPEXT	Eroknow	Erocause	Eroeffect	PEROSUM
ADOPT	Pearson correlation	1	0.578**	0.196*	0.021	0.102	0.129
	Sig. (2-tailed)	-	0.000	0.016	0.798	0.213	0.115
ADOPEXT	Pearson correlation	0.578**	1	0.308**	0.096	0.182*	0.237**
	Sig. (2-tailed)	0.000	-	0.000	0.244	0.026	0.003
Eroknow	Pearson correlation	0.196*	0.308**	1	0.465**	0.599**	0.835**
	Sig. (2-tailed)	0.016	0.000	-	0.000	0.000	0.000
Erocause	Pearson correlation	0.021	0.096	0.465**	1	0.523**	0.802**
	Sig. (2-tailed)	0.798	0.244	0.000		0.000	0.000
Eroeffect	Pearson correlation	0.102	0.182*	0.599**	0.523**	1	0.847**
	Sig. (2-tailed)	0.213	0.026	0.000	0.000		0.000
PEROSUM	Pearson correlation	0.129	0.237**	0.835**	0.802**	0.847**	1
	Sig. (2-tailed)	0.115	0.003	0.000	0.000	0.000	-

**Correlation is significant at the 0.01 level (2-tailed). Erocause = erosion cause, Eroeffect = erosion effect; * Correlation is significant at the 0.05 level (2-tailed). Eroknow = erosion known; N=150.

of agro-pastoralists about the cause and effects of erosion, but their interrelationship is statistically insignificant (at $p = 0.5$, and below). Perceiving the importance of the soil erosion problem and positive effect of soil conservation measures also provides a stimulus to, and shapes opinions about, accepting the merits of adopting conservation practices that stop the problem (Long, 2003; Habtamu, 2006). The Pearson product-moment correlation coefficient shows that the extent of adoption of soil and water conservation technologies of agro-pastoralists is significantly and positively correlated with their perception level on soil erosion ($r = 0.308$, $p < 0.01$) and its effect ($r = 0.182$, $p < 0.05$), but positively and insignificantly correlated with agro-pastoralists perception level on cause of erosion. The overall Likert value of farmers' perception on erosion, its cause and effect, are positively and significantly correlated with adoption extent (with $r = 0.237$, $p < 0.01$). Hence in the study area, those agro-pastoralists having a better perception on soil erosion use more soil and water conservation techniques, and the reverse is true for those having lower perception on erosion, its cause and effects (Morgan, 2005).

The relationship between agro-pastoralists' perception on erosion and other factors

Table 7 presents the correlation coefficients for the relationship of the agro-pastoralists' perception on erosion with 13 other factors. As presented in Table 7, Pearson product-moment correlation coefficients show that the age, number of children and access to credit are the three factors negatively and significantly correlated with the respondents' perceptions at $p < 0.1$, and their marital status, land security, size of farm and number of livestock are insignificantly affecting the agro-pastoralists' perception on erosion. However, household head's perception on soil erosion is positively and significantly correlated with his/her educational status, participation on soil and water conservation campaign and access to extension and training (at $p<0.01$). Similar results are reported by Detamo (2011) for the relationship between education and perception of farmers; namely, that illiterate farmers differ in perceiving the soil erosion problem compared with educated farmers, and uneducated farmers are likely to differ in practicing soil conservation measures compared with educated farmers. On the other hand, gender, off-farm activity and farming experience are positively, but insignificantly, interrelated with their perception on erosion.

Soil and water conservation measures

Practices of soil and water conservation in the study area

Until 1995, the Aba'ala Woreda remained unexposed to any sort of development activity supported by external donors. However, in 1995 the Dryland Husbandry Project (DHP) was initiated and later in 1998 the Afar Integrated Pastoral Development Program (AIPDP) began a pilot phase in Aba'ala Woreda. The agro-pastoralists, while they have a wealth of knowledge on water sharing, they have no experience in field-level soil moisture conservation as well as agronomy. They did not practice

Table 7. Factors related to agro-pastoralists' perception on soil erosion.

Variable		PEROSUM	GEN	Age	MARST	EDUC	Children	Of farm	Lantenur	FM size	Partcamp	Accredit	Extension	Fertility	Livestock
	Pearson correlation	1	0.135	-0.361**	-0.048	0.649**	-0.264**	0.104	-0.154	-0.159	0.230**	-0.550**	0.276**	0.069	-0.059
PEROSUM	Sig. (2-tailed)	-	0.101	0.000	0.563	0.000	0.001	0.205	0.060	0.056	0.005	0.000	0.001	0.400	0.473
	N	150	150	147	147	150	150	150	150	145	147	144	150	150	150

**Note: Gen= gender, AGE= age, MARST= marital status, EDUC= educational status, FMSIZE=family size, PEROSUM = person sum, OFFARM = farm size.

intercropping and their fields have no field bunds (Solomon and Abebe, 2012).

As the amount and distribution of rainfall over the growing period of long season crops is very low, the crops planted in the lowland areas of Aba'ala valley, particularly sorghum and maize, suffer from moisture stress during the later stages of growth (from seed filling to full maturity). To overcome this problem, people traditionally divert flood water to use as supplementary irrigation.

Spate irrigation is a type of river basin water management that is unique to semi-arid environments. In spate irrigation systems, floods that are generated by heavy rainfall in upper sub-basins can be diverted from normally dry wadis (ephemeral streams) and distributed using earthen, brushwood or concrete structures to irrigate low-lying fields.

Traditionally, floods are diverted using a temporary diversion structure made of tree branches, soil and stone. This flood is delivered using open channels which are dug both at the left and right banks of the river as intake, which is reinforced by stones, boulders, shrubs and logs.

The agro-pastoral people living within the Aba'ala plains faced difficulties in diverting the flood water before the modernization program of creating a diversion structure by AIPDP. The traditional means of diversion demands cutting trees and frequent maintenance of the structures. In order to support the community effort to divert flood water, under AIPDP in 2007-2009, flood water diversion was designed and implemented using gabions in four of the rivers (Aba'ala, May-Shugala, Murga and Leina rivers) that drain to the Aba'ala plain. But, nowadays, this program is not serving the community.

Analysis of current adoption and failure

As depicted in Table 8, 74% of the farmers adopted and used SWC techniques on their farmland and the other 7.3% have stopped using any of SWC techniques. The remaining 18.7% of agro-pastoralists did not adopt any of SWC measure, so far. However, the researcher assumes that an agro-pastoralist who applied any measure including contour plowing is included in the study as adopted farmers. This poor adoption and use of SWC measures in the study area can be more fully understood in relation to the 'theoretical and conceptual frame' presented below.

Extent of adoption of SWC measures in the study area

Theoretical and conceptual frame

According to Semgalawe (1998), adoption of soil conservation technologies has been described based on varied criteria. These include type of conservation practices; number of conservation practices and land area under conservation measures. In this research, the first two criteria are used to describe adoption of SWC practices of the study area.

Hence, the designation of Very high adoption applied at least to two of the three SWC (physical, biological and soil management SWC) techniques. The category of High adoption applied to only one of the three SWC techniques, Moderate adoption, was found for at least one type of SWC technique, Low adoption applied to more than one type of SWC measures, while Very low adoption applied to only one type of SWC techniques. As the result showed in Table 9, 33.3% are under *very low adoption*, and 22.0% are under *low adoption* (Table 9).

The people did not experience practicing all three types of SWC methods on their land. They experienced mostly structural changes such as gabions and bunds, and agronomic methods such as fallowing. Biological soil conservation methods were practiced by some farmers, but they almost stopped using this nowadays. This is because they lacked a possibility to apply the measures like water shortage for composting and manure, as some farmers reported.

The study on practice of spate irrigation in the area by AIPDP by Solomon and Abebe (2012)

Table 8. Agro-pastoralist adoption of soil and water conservation measures

Variable	Frequency	Percentage
Did not adopted any SWC measure	28	18.7
Adopted and using SWC measures	111	74.0
Stopped using all SWC measures	11	7.3
Total	150	100.0

Table 9. Adoption extent of SWC techniques in the study area.

Adoption extent		Frequency	Percentage	Valid percentage	Cumulative percentage
Valid	Not adopted	28	18.7	18.7	18.7
	High adoption	13	8.7	8.7	27.3
	Moderate adoption	26	17.3	17.3	44.7
	Low adoption	33	22.0	22.0	66.7
	very low adoption	50	33.3	33.3	100.0
	Total	150	100.0	100.0	-

showed that, although agro-pastoralists have a knowledge on water sharing, they have no experience in field-level soil moisture conservation as well as agronomy. As discussions with respondents in this study showed, there is no wide use of different biological, agronomic and soil management techniques in the area. They did not have widely organized governmental programs on this issue.

What are the major SWC techniques used in the area?

Generally, in the study area, relatively, structural soil and water conservations are used in arresting soil erosion and river flooding by water prevailing in the area. The practiced structural soil and water conservations measure practiced in Aba'alla district are presented in Table 10 and discussed more fully in the subsequent sections below.

Structural SWC measures

Gabion structures

As shown in Table 10, most of the respondents used Gabion structures and contour bunds. Gabion baskets which are designed to serve for a design period of 5 to 10 years were constructed in the Aba'ala River to improve the flood diversion efficiency and minimize the challenges faced with traditional diversion systems by AIPD in 2009 (Figure 6). In addition to this, the farmers reasoned out that they use these structures mainly because of the availability of construction materials locally.

Bunds, terraces and panya juu

The use of stone bund is still common in the study site. About 52 farmers replied that mostly farmers used stone bunds and a few farmers practice panyajuu, Bench terraces and Half-moons.

Furrows and ditch

Ditches or water ways and furrows are mostly used by farmers during flooding and water diversion to their field through tertiary canals. It is being used as a main diversion structure of flooding and discharge water around towns.

Fencing and area closure

About 30 households responded that they use fencing. As the field observation by researchers showed, the farmers use fencing in order to bound their irrigation land and to keep the safety of the crops.

Biological/Agronomic SWC measures

Agro-forestry, Mulching, Composting, Manure, Strip cropping and fallowing: As Table 10 indicates, these

SWC methods were almost not in use currently, except

Table 10. Types of SWC technologies used by respondents.

Item	Responder response (frequency)		
What types of SWC technologies you use?	**Using at present**	**Used sometimes in the past**	**Total usage**
Contour bund	34	4	48
Earthen bund	5	10	15
Stone bund	42	6	48
Gabions/check dams	86	7	93
Panya juu	23	8	31
Half moon	3	6	9
Mulching	2	18	20
Manure	2	5	7
Composting	-	6	6
Bench terraces	6	-	6
Crop residue	23	38	51
Crop rotation	22	11	33
Strip farming/cropping	-	6	6
Multiple cropping	-	-	-
Contour plowing	43	-	41
Fencing	30	5	35
Area closure	2	-	2
furrow	4	7	11
Water ways/ditch	11	2	13
Agro-forestry	-	3	3
Planting basins/ pitting	-	-	-
Fallowing	31	-	31
Minimum tillage	14	3	17

for fallowing to simply use the rest for farmland, rather than bothering to grow fallow crops.

Soil management methods: This method is concerned with ways of preparing the soil to promote dense vegetative growth and improve the soil structure so that it is more resistant to erosion.

Conservation tillage (Contour plowing/tillage, ridging and minimum tillage) and Crop rotation: Contour farming and minimum tillage are relatively in wider usage by the agro-pastoral community in the study area. Some of the farmers also use crop rotation methods. The survey result also showed that some agro-pastoralists even do not have the knowhow about when and how to plow the land. About 43% of respondents plow their land when they decide to plow, 32% plow only when it is needed, 21% plow pre-irrigation and 4% did not know it.

Preference and failure: The farmers prefer SWC technology like stone gabions, bunds, soil bunds fallowing/giving rest, contour plow and the likes. Among the aforementioned listed factors, the farmers' preference is slightly different through type of technologies they use. The most dominant factors that lead them to prefer the technologies are their easiness to use, cost creepiness, and peoples' appreciation. In addition to these, data in Table 10 shows that some agro-pastoralists stopped using some technologies and chose some others (7.3%). The factors for the failure can be seen as lack of money to invest, its difficulty to apply and keep.

Factors affecting farmers decision to adopt of soil and water conservation: There are different demographic, socio-economic, institutional and biophysical factors which affected the adoption decision of farmers in the study area.

Demographic factors

Rogers (1995) stated that the characteristics of a given technology are important determinants of adoption. In addition, the characteristics of the farmers such as age,

Figure 6. Improved Gabion basket for river diversion (Solomon and Abebe, 2012).

household size, farm size, education, experience and the farming enterprises are factors that influence the adoption decision.

From among the demographic factors, educational status is the most important positively correlated factor affecting the probability of farmers' adoption of SWC technologies significantly ($r = 0.0258$, $p < 0.01$). Exposure to education may enhance the awareness of a new technology and increase the capacity of the farmers to apply a given technology. This is similar with the finding of Ntege-Nanyeenya et al. (1997) and Nkonya. (2002) in the case of Uganda where they reported that education had a significant effect on farmers' choice to adopt maize production technologies.

The results of this study findings show that age negatively, but insignificantly, affected the adoption. This is also similar with the study done by Lapar and Pandey (1999) for Philippines, Shiferaw and Holden (1999), for Ethiopia and Featherstone and Goodwin (1993) for USA. They reported that farmer's age is negatively related to adoption of soil conservation practices. Similar results have been reported for the factors of gender, number of children and marital status of households. But, the size of the household has been identified to positively influence the rate of fertilizer adoption in Eastern Oromia, and the probability of adopting of improved fallow in Zambia (Keil, 2001).

Farming experience can also determine a farmers' awareness and interest in a given technology and their ability to implement it. In a study conducted in Northern Tanzania, farming experience was the most important factor positively affecting the probability of adoption of improved maize seed (Nkonya, 2002). Similarly, our study showed that farming experience is positively significant with adoption at $p < 0.05$.

Socio-economic factors

The findings that socio economic factors affect the decision of farmers on SWC, and determine households' interest and acceptance to use conservation practices, are supported by diffusion of innovation schools opened up in the area for adoption and human behaviors (Rogers, 1995). The survey results of this study indicate that socio-economic level, perception of erosion occurrence, farm experience and non-farm income have positive influence, whereas farm size and livestock owned have negative influence, on adoption of soil and water conservation in the study area; but their effect is statistically insignificant at the 0.05 level.

Institutional factors

The farmers' participation in the SWC campaign, access to agricultural extension services and training on land security are factors considered in this study. Access to agricultural extension services is necessary to provide information and enhance the knowledge and skills of farmers. The information obtained and the knowledge and skills gained through training accelerates farmer's decision to adopt soil and water conservation practices.

As this survey showed most of the farmers did not get extension service advice. There is also a positive and significant correlation between access to extension service and adoption of SWC technologies ($p < 0.05$). This result is similar with finding of Semgalawe (1998), Tesfaye (2003), Wogayehu and Lars (2003) and Yitayal (2004) for households that have access to institutional support such as extension services, soil and water conservation program, access to subsidized inputs, information and better understanding of the land degradation problem, and soil conservation practices.

Households that participate in labor sharing groups through soil and water conservation programs like, in our case, participation on a mass SWC campaign, are expected to have more knowledge, affection and get more incentives to adopt conservation measures than others. As described previously, the agro-pastoralists participation on this campaign is very low. But it positively affects the adoption behavior of the farmers, although its correlation is insignificant.

The land tenure pattern of the nation also affects the decision of farmers on soil and water conservation practices, but in this study its correlation with adoption extent is negative and significant ($p < 0.05$). The incentives given by external organizations to farmers through food for work either encourages, or sometimes discourages, farmers to use improved soil and water conservation measures.

Physical factors

The result of the finding showed that physical factors such as topography (slope) and soil fertility had no significant effect on the adoption of soil and water conservation. However, their relationship is positive for those farmers having fertile soil and gentler slope, and farmers having steeper and less fertile soil tend to adopt more technologies.

Conclusions

The study aimed at accessing agro-pastoralists' adoption of soil and water conservation measures in Aba'alla Woreda. The study indicated that a large number of household heads are more in the medium and younger age group than elder ones. About 85.3% were male-headed households and 14.7% were female headed households. The finding indicated that 51.33, 34.67 and 14.00% of the sample household have respectively: more than 5 children, 3 to 4 children and 1 to 2 children. About 46 % of the household heads had no formal education or are illiterate, 35.3% of the respondents had a primary education, 10.7% completed secondary schooling, and only 8.0 % pursued further education.

In Aba'ala, many farmers operate a land on a sharecropping basis through renting of land. About 41.3 %, 24.0% and 22.7 % of the respondents' said soil fertility in the area is medium, low and high, respectively. About 68% of farmers did not get extension services, except for the remaining 32% who did. There are also positive and significant correlations between access to extension service and adoption of the technologies ($p < 0.01$).Most of the farmers (72.0%) didn't have access to credit at all.

The probability of the agro-pastoralists' for adopting and not adopting is significantly related with their perception on erosion($r = 0.196$, $p < 0.05$). Specifically, adoption increases with increasing positive perceptions of the cause and effects of erosion, but their interrelationship is statistically insignificant (at $p = 0.5$). Similarly, Pearson correlation coefficients show the extent of adoption of soil and water conservation technologies of agro-pastoralists is significantly and positively correlated with their perception level of the issues with soil erosion ($r = 0.308$, $p<0.01$) and its effect ($r = 0.182$, $p<0.05$).

Pearson correlation coefficients show that the age, number of children and access to credit are factors negatively and significantly correlated ($p < 0.1$) and marital status, land security, size of farm and number of livestock are insignificantly affecting the agro-pastoralists' perceptions on erosion. However, household head's perception on soil erosion is positively and significantly correlated with his/her educational status, participation on soil and water conservation campaigns and access to extension and training ($p < 0.01$). On the other hand, gender, off-farm activity and farming experience are positively interrelated with their perception on erosion.

The use of biological soil conservation methods was practiced by some farmers, but they almost stopped using the technology nowadays. The study indicates agronomic SWC methods currently used were only a few. From these methods, contour farming and minimum tillage are relatively in wider usage by the agro-pastoral community in the study area. Some of the farmers also use crop rotation methods. From among the demographic factors, educational status is the most important positively correlated factor that significantly affected the probability of farmers' adoption of SWC technologies ($r = 0.258$, $p < 0.01$).

Socio-economically, perceptions on erosion problems, farm experience and non-farm income have positive correlations with adoption of SWC, whereas farm size and livestock owned have negative influence on adoption of soil and water conservation in the study area, and their effect is statistically insignificant. There is also a positive and significant correlation between access to extension service and adoption of SWC technologies ($p < 0.05$). The effect of land tenure on adoption extent is negative and significant ($p < 0.05$). Physical factors such as topography (slope) and soil fertility have no significant effect on the adoption of soil and water conservation.

RECOMMENDATIONS

Flood irrigation is the most problematic, if not the most serious, concern. Based on the finding the researchers generated, the following recommendations for the changes are made:

(1) The government should do on the attitude of agro-pastoral peoples to have a good awareness on water sharing, agronomy and soil fertility management.
(2) All of us must do on adoption extent of SWC methods to elucidate the problem.
(3) For agro-pastoral farmers, government must give training on environment and SWC techniques to equip them on the concept and their importance.
(4) To aware farmer's perception on occurrence of erosion problem, through participation of mass SWC campaign which have a positive significant effect on their adoption.
(5) Announcing the farmer and experts on spate irrigation.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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