

# The role of indigenous knowledge and practice in water and soil conservation management in Albuko Woreda, Ethiopia

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**Abstract** Taye A, Megento TL. 2017. The role of indigenous knowledge and practice on water and soil conservation management in Albuko Woreda, Ethiopia. *Bonorowo Wetlands* 7: 95-107. The objectives of this study were to assess various aspects of indigenous knowledge and practice in water and soil conservation measures introduced in Albuko Woreda/district, South Wollo, Ethiopia, and investigate how farmers have adopted indigenous soil and water conservation measures. This study also aimed to examine farmers' views on land degradation and assess their adoption behavior of soil and water conservation knowledge. The data for the study originated mainly from farmers in the study area. Structured questionnaire survey and focus group discussion methods were applied to collect the necessary information from farm households. A total of 140 heads of families were questioned. The received data was analyzed using descriptive statistics and quantitative and qualitative data analysis. Even though some soil and water conservation methods were introduced to combat land degradation in Ethiopia, adopting these practices remains below expectations. Most farmers preferred soil (stone) bund, water diversion ditch and contour ploughing for soil and water conservation, crop rotation, and mixed cropping for soil fertility amendment measures instead of traditional cutoff drain and fallowing. Farmers faced several constraints in adopting soil and water conservation measures. The main problems related to conservation structures include the source of pests, inconveniency during ox ploughing, reduction of farmland, labor intensiveness, difficulty in implementation, and costliness. In contrast, farmers were knowledgeable about various indigenous soil and water conservation measures but implemented only some of them. They understand the effects of erosion on crop productivity. Finally, farmers need to be trained on the impact of soil erosion and available conservation measures. Information on the ineffectiveness of some traditional conservation measures has to be disseminated among farmers.

**Keywords:** Farmer, indigenous knowledge, land degradation, soil, and water conservation

## INTRODUCTION

Culture and the respective systems of indigenous peoples have been widely misunderstood or even dismissed by development planning experts in the past. This issue was raised recently in a final statement by the Brundtland Commission (WCED): "Some traditional lifestyles are threatened with virtual extinction by insensitive development over which the indigenous people have no participation. Their traditional rights should be recognized, and they should be given a more decisive voice in formulating policies about resource development in their areas" (Our Common Future 1987).

Many scientific and social researchers associated with developing assistance policies are now beginning to recognize the decisive role that indigenous peoples and their knowledge of the ecosystem contribute to in the success of development projects and strategies (Lalonde 1991). It is reasonable to assume that essential global development assistance activities including; local participation, capacity building, and sustainable resource management can be enhanced in cost-effective programs and strategies that understand and work with indigenous knowledge and decision-making systems. Africa may be an ideal continent to learn about and begin thoughtfully integrating indigenous expertise with development planning techniques. Despite the rich diversity and number

of indigenous cultural groups throughout Africa, much of the remaining areas of Africa today are threatened by growing environmental and social pressures. In this unexploited, remote, or sparsely populated area, the indigenous societies tend to live traditional lifestyles (Lalonde 1991).

Indigenous knowledge (IK) has attracted the interest of researchers nowadays. Accordingly, various investigators tried to recognize how conservation of natural resources such as water and soil can be done through indigenous knowledge of communities compared to modern ways. In this regard, (IIRR 1996) argues that IK is adapted to local culture and environment, based on experience, habitually established over centuries of use, dynamic, and changing. Likewise, Ajibade (2003) conceptualizes IK as it has been built upon and passed from one generation to generation and improves within a particular culture or ethnic group, and tries to continue objectives in a specific environmental background.

The densely residential areas of Northern Ethiopia are among those with the highest rate of soil loss because the environment is highly degraded compared to the Southern part of the country. The country's forest reserves are predicted to be 2.5-3% of the total land, where approximately 100,000 hectares of forest are lost annually. About 1 billion tons of topsoil are also believed to be eroded annually (Berisso 1995). In line with this, Tsighe

(1995) asserts that the average soil erosion is 42 tones/hectare/ year in the croplands.

It is well-known that soils with low fertility cannot allow sufficient crop cover to sustain life. Low humus content and erosion of such soil decrease infiltration and moisture-holding capacity of the soil. Thus, it is increasingly recognized that adequate conservation of soil resources is a precondition for sustainable rural development strategies, mainly in the highlands of Ethiopia. Most of the projects for soil conservation, however, planned at the center and implemented at the local level, show little attention to whether the local population could apply techniques on their farm fields. Similar to the above experience, farmers did not want to expand new methods to the rest of the farm fields at the end of the project. This is partially attributed to the costly nature and problem of adaptability of the latest technology otherwise not contextualized. Furthermore, planners in the area assume that the local population is responsible for the overall maintenance of the structures built by a project (Tsighe 1995).

Most highland areas of Ethiopia are characterized by high population, high rainfall, and sloppy lands. Maintaining the fertility of the productive soil and rehabilitating degraded arable lands are the primary concern of many stakeholders in highland areas (Amede et al. 2001).

Likewise, soil erosion is one of the major agricultural problems in the Ethiopian highlands. The highlands occupy 44% of the country's total area, 95% of the land under crops and 90% of the total population, and 75% livestock. Deforestation, overgrazing, and cultivation of slopes not suited to agriculture, together with the farming practice that does not include conservation measures are the primary causes for soil erosion in much of Ethiopia's highland

areas. Population pressure and soil erosion in the regions are critical causes for declining arable lands. The decrease in the productivity of arable lands in the highlands is due to the washing away of the fertile topsoil by water erosion (Amede et al. 2001). Hence, this research assessed the indigenous knowledge applied in the Albuko *woreda* of the South Wollo.

The specific objectives of this study are to (i) identify the traditional and indigenous soil and water conservation practices in the *woreda*; (ii) examine the extent of indigenous water conservation measures (soil water conservation) practices as they appeared in the *woreda*; (iii) to assess the most commonly and rarely used indigenous practices of soil water conservation in the *woreda*; (iv) assess the socio-cultural, economic, biophysical system and constraints for the implementation and maintenance of indigenous soil and water conservation practices; and; (v) analyze farmers' knowledge towards determining the degree of land degradation in the *woreda*.

**MATERIALS AND METHODS**

**Description of the study area**

*Location*

The Amhara national, the regional state, is located in the country's central, northeastern and northwestern parts, between 9°-13° 45''N and 36°-40° 30''E (Figure 1). According to the latest GIS mapping, the Amhara regional state covers about 157,647 km<sup>2</sup> or around 14% of the country's land area. The highlands of the Amhara region (>1500 m asl.) account for 73% of the region's land area, with the lowlands sharing 27% (MoA 2002).

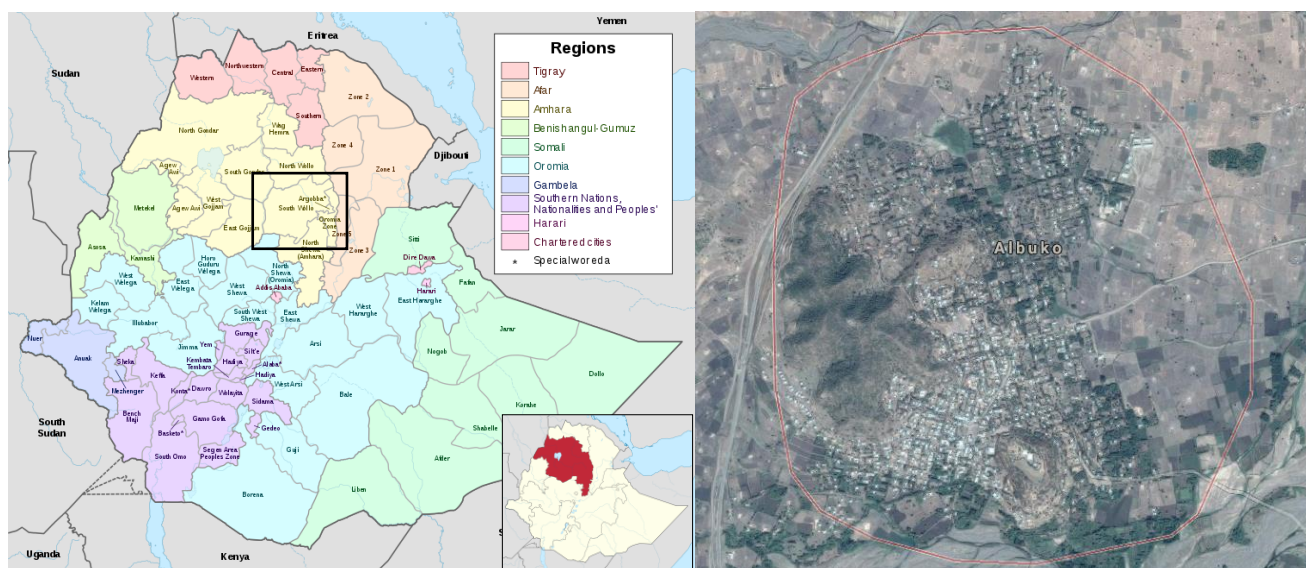


Figure 1. Study site in Albuko Woreda, South Wollo, Amhara, Ethiopia

Albuko *Woreda* is situated in the northeastern highlands of the Amhara region, at a distance of about 37km from Dessie in the southeast direction, on 11000` N and 39039` E. Weyna Dega defines the characteristic of the agro-climatic zone to which the site belongs to Dega. The range of altitude lies from 2530-2860 m.a.s.l. The primary type of soils in the area are Phaeozems/Lithosols 56%, Phaeozems 37.6%, Gleysols 2.5%, Fluvisols 2.2%, and Regosols 1.7% coverage. The catchment's mean annual (1982-1989, 1992-1993) precipitation is 1211 mm with a bimodal characteristic regime. The mean yearly erosivity amounts to 4267 MJ mm ha<sup>-1</sup> hr<sup>-1</sup> (Bosshart 1999; SCRP 2000). The catchment is low-potential, intensively cultivated, and part of the ox-plow cereal belt in the highlands of northeastern escarpment (SCRP 1982).

#### Population

According to figures published by the Central Statistical Agency in July 2011 (CSA 2011), this *woreda* has an estimated total population of 82,311, consisting of 41,010 males and 41,301 females. Albuko has a population density of approximately 172.7 people per square kilometer from an entire area of 476.68 square kilometers, which is higher than the Zonal average of 158.7 and the regional average of 119.9 people per square kilometer.

#### Topography

According to the Geological Map of Ethiopia (Ministry of Mines 1973, in Tesfaye 1988), the research area consists of alkaline olivine basalts and tuffs of the Ashangi Groups (Paleocene-Oligocene-Miocene), which are part of the volcanic trap series. The area is part of the Afar Margin, and the tectonics is dominated by graben faulting. Results of Weigel's (1986) soil survey demonstrated that the Albuko area is dominated by steep (25-55%) and very steep (more than 55%) slopes, which cover two-thirds of the survey area.

#### Temperature

The minimum air and soil surface temperatures were 3-4°C, and the maximum was 28-35°C, respectively (SCRP 2000). April to June are the warmest months with a mean monthly minimum soil temperature of 12.0°C. The maximum soil temperature goes up to 16°C between November and January.

#### Rainfall

According to SCRP (2000), the rainfall of the research area is mainly influenced by the Inter-Tropical Convergence Zone (ITCZ) and the sub-tropical pressure cells, resulting in the area's annual rainfall variable. The primary rainy season (*Kremt*) occurs typically from June to October, with the peak rainfall in August, then declining markedly in September and October.

According to monthly rainfall distributions, Albuko is bimodal, having *Belg* (slight rain between February and May) and *Kremt* (the primary rainy season between July and September). The rainfall distribution during the *Belg* season is between 69.5 mm and 112.7 mm, with peak rainfall in April and peak erosivity of 658 MJ mm ha<sup>-1</sup> in

March. The rainfall distribution during the *Kremt* season is between 140.9 mm and 287.8 mm, with peak rainfall in August and a peak erosivity value of 905 MJ mm ha<sup>-1</sup>.

#### Farming system

Small-scale farming is considered the most prevalent method in the catchments for maintaining a subsistence economy at the household level. Farmers usually own draught animals. Thus, plowing is traditionally done with the traditional tool called *maresha*. The crops are produced during two cropping seasons, *meher* and *belg*. During *belg* season, the most important crops are barley, whereas emmer wheat, maize, horse bean, and *teff* are the most important ones in the *meher* season. No fixed cropping sequence is employed because each plant is grown on suitable sites. Planting is started immediately after the first adequate rainfall in the rainy season on the land that has been plowed. Different tillage and land preparation requirement before cultivation is needed for each crop. Cereals require the highest number of plowings, whereas pulses are plowed only once or twice. Seedbed which prepared for *teff* plantation needs some tillage frequency than others. Fields are left to lay fallow in areas where alternative fields are available and when the soil is depleted (Hanggi 1997).

#### Soil and water degradation

Water and soil degradation, recurrent drought, small farm plots, high population density, and input shortage, including draught animals and improved seed, are the primary agricultural problems of the *woreda*. These agricultural production problems are enhanced with inadequate research technology and extension support delivery. Cash income for household financial requirements is mainly generated from the sale of livestock and crop products. Households facing seasonal food shortages receive cash or food transfer, either "for work" (through a public work program to employ beneficiaries in soil water conservation works, building roads and other infrastructures) or "for free," from productive safety net program (PSNP).

#### Types of data and source

This study is based on data obtained from primary and secondary sources. The literature review entirely depends on secondary sources. All analysis depends on primary and secondary data, collected through unstructured personal interviews and questionnaires from randomly selected households, and secondary data obtained from various published and unpublished sources of the governmental and non-governmental organizations. Books, journals, internet sources, research reports, archives, and records were employed for acquiring the necessary information.

#### Household survey

A formal survey questionnaire was used to gather primary household data at the village level. Preliminary data was also generated by interviewing local extension agents. Also, direct field observations and some informal discussions with farmers groups, village elders, and

extension workers were conducted to verify information of interest to this study. This questionnaire was prepared, tested, and amended to fulfill the objectives of the present study.

#### Sampling technique

If resources and time are available, the entire population should be studied to provide the most accurate results. Nevertheless, resources are never abundant, and time is never unlimited. This urges for taking samples from the population. This method is a convenient and cost-saving approach to a research study (Asraf and Brewer 2004).

In the study area, there are 14 *kebeles* (lowest administrative units in Ethiopia). All of them are identified and listed down from which three sample *kebeles*, namely Maybar, Soba, and Tulutosigne, were selected using the purposive sampling method. The total households of Maybar, Soba, and Tulutosigne *kebeles* were 612, 693, and 711, respectively (Table 1). Seven percent of each *kebele's* households were selected using a simple random sampling technique, making the total sample 140.

Given the relative homogeneity of the subsistence farmers in the study villages (*kebeles*) regarding physical environmental factors and resource endowments, this number was considered maximum, which could be efficiently handled within the research time and budget.

#### Interview

Interviews at the household level were carried out by going to each interviewee's homestead by the researcher. A randomly selected sample substitute was included in cases where the selected interviewees may not be interviewed for various reasons. The purpose of this interview was to acquire primary household data. Informal discussions with village elders and farmers groups were conducted using a checklist of topics to guide the sessions. This interview was conducted to cross-check household data and obtain reliable data for the entire study.

#### Key informants interview

The final level of the informal interview was conducted with village extension workers. The interviews were intended to gather information about the type of soil conservation and fertility practice, farming practices, extent of using market inputs such as fertilizers, improved seeds, and the nature of extension services offered and to establish a communication gap between farmers and extension workers.

**Table 1.** Total household heads of the three *kebeles* and sample size taken

Study villages ( <i>kebeles</i> )	Average elevation (m asl.)	Climatic zone	Total no. of households	Sample size (7%)
Maybar	2530-2860	Temperate	612	42
Soba	2530-2860	Temperate	693	48
Tulutosigne	2530-2860	Temperate	711	50
Total			2016	140

#### Focus Group Discussion

Focus group discussions with six to eight discussants in each group were carried out on different local people's indigenous soil conservation mechanisms issues. The discussions focused on native and modern soil conservation mechanisms.

#### Data analysis

The survey generated qualitative and quantitative data; the first task was to summarize, categorize, and code all qualitative responses into numeric values and then enter them into the SPSS statistical program. The quantitative data was for analysis of various parameters.

Information obtained from unstructured interviews and informal interviews with different seniors in the village and extension officers was mainly verbal/narrative information. These were written down during the survey and summarized. This information is more qualitative and supports the coded qualitative and quantitative data analysis. Descriptive statistics such as sum, mean, and percentages are presented in tables to enable interpretation and quick visual comparisons of variables within the study area.

## RESULTS AND DISCUSSION

### Demographic characteristics

#### Family size of the households

As shown in Table 2, 38% of the respondents have 1-3 family size, 41% of the household heads have 4-6 family size and 15%, and 6% of the households have 7-9 and above nine family size, respectively. This shows that the household heads have a large family size that contributes to the positive impact on the soil water conservation practice in the *woreda*. Family size helps efficiently take on some soil and water conservation practice measures in their farmlands.

The mean household size is 6.03 persons. The average household size in Maybar, Soba, and Tulutosigne village are 5.5, 5.9, and 6.7, respectively. The household size refers to the number of individuals currently living under one roof, excluding children of some households who may have established their families.

#### Sex of the household members

The entire population of the 140 households is 844, consisting of 416 males and 428 females (Table 3). Of the whole 140 sample households, the result indicates that 49.3% of the household members are males. Comparing the regional figure based on figures published by the Central Statistical Agency in July 2011, this *woreda* has a total population of 82,311, of whom 41,010 were males, and 41,301 were females. A similar result is shown from the survey concerning male and female population proportion in the study area, specifically in three *kebeles*.

#### Age of the heads of household

As we can see from Table 4, 45% of the respondents were between 20-34 years old, 37% of the respondents

between 35-49, whereas 10% and 8% of the household age group were from 50-64 years and more than 65 years old, respectively. This phenomenon reflects that almost all the household heads are adults and obtain enough experience in their lifetime. This might contribute to implementing the indigenous soil and water conservation programs. The mean household age is 42, similar to Maybar, Soba, and Tulutosigne villages.

#### *Education level of the heads of household*

Education is one of the fundamental human needs that all human beings deserve for the proper understanding of social, economic, political, and natural environments in which individual lives. In this study, concerning the educational background of the respondents, as we can see from Table 5, about 33.6% of the household heads are illiterate. Meanwhile, 42.9%, 15.7%, 7.1%, and 7% of the respondents have 1-4, 5-8, 9-12, and above 12 grades of education, respectively. The above result indicates that most of the respondents have a low level of educational qualification that might become a challenge for adopting new soil water conservation technologies.

#### **Landholding**

Land availability often affects farming practice and the land degradation process. The majority of the agricultural land in the study area has been subdivided into the smallest landholdings, which are no longer economically viable for smallholders' subsistence. Farmers in the study cannot expand landholdings because the frontier is limited. Furthermore, the availability of arable land has shrunk dramatically from 0.42 to 0.23 ha per capita in the past 30 years (CSA 2005).

As Table 6 shows, almost all respondents have their farmlands. Nevertheless, the farmland size of the first 27 respondents is decreasing from year to year. The main reason for the reduction of their farm size is attributed to land degradation (presented in Figure 2) and need for housing by themselves for their children, and unanticipated road construction by the government. On the other hand, 69.3% of the respondents said their farmland is scattered. Regarding farmland cultivation, 76.4% of the respondents agree that they are cultivating their farm, whereas the rest, about 23.6%, are not developing all of their lands. The researcher took a photograph to show the degraded land (which is described by the farmer as one of the reasons for farmland size decreasing) in the *woreda* (Figure 2).

It is apparent from the preceding observation that there is intense pressure on the villages' land due to limited arable and grazing land, increasing family size, and lack of off-farm employment. Rapid population growth and limited arable land have increased pressure on the forest and grazing land resources besides aggravating soil degradation via extended farming into steep and marginal areas, shortened fallow system, tilling more frequently, and unchecked depletion of the inherent soil nutrients (Gizachew 1995).

In the study area, farmers cannot expand landholdings because the frontier is limited, and the availability of arable land has shrunk dramatically from time to time. Farmers'

responses also revealed the existing land shortage in the study area. As we can see from Table 7, each household has an average of 0.79 ha of land. From 140 total interviewed farmers, more than 80% of households reported that their current landholdings are too small compared to the area needs of the family, and they are not in a position to inherit land to their children. Young male farmers inherited property from their parents when they got married. However, with married children living with parents until their death, multigenerational households have become more common as household landholdings have decreased. As shown in Table 6, over 90% of sampled households have less than 1.0 hectares of land.

**Table 2.** Family size distribution of respondents (N=140)

Family size	Maybar	Soba	Tulutosign	Total
1-3	16	38	19	40
4-6	17	41	21	44
7-9	6	14	6	12
>9	3	7	2	4
Total	42	100	48	100
Mean	5.5	5.9	6.7	6.03

**Table 3.** The demographic composition of the sample households, number of individuals by sex

Sex	Maybar	Soba	Tulutosign	Total
Male	125	51.4	137	48.8
Female	118	48.6	144	51.2
Total	243	100	281	100

**Table 4.** Age distribution of respondents (N=140)

Age	Frequency	Percent	Mean of household age
20-34	63	45	42
35-49	52	37	
50-64	14	10	
>65	11	8	
Total	140	100	

**Table 5.** Educational level of the sample respondents (N=140)

Educational level	Freq.	Percent	Valid percent	Cumulative percent
Illiterate	47	33.6	33.6	33.6
1-4	60	42.9	42.9	76.4
5-8	22	15.7	15.7	92.1
9-12	10	7.1	7.1	99.3
>12	1	.7	.7	100.0
Total	140	100.0	100.0	

**Table 6.** Information on land ownership, scattered land, and cultivation status

Response of household	Own farmland		Scattered farmland		Cultivate farmland		Change on the size of farmland	
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Freq.	Percent
Yes	140	100	97	69.3	107	76.4	27	19.3
No	0	0	43	30.7	33	23.6	113	80.7
Total	140	100	140	100	140	100	140	100

**Table 7.** Landholding of the household in Albuko Woreda, Ethiopia

Size of land in Hectare	Frequency	Percent	Mean	SD
0-0.2	22	15.7	0.79	0.34
0.3-0.5	10	7.1		
0.6-0.8	60	42.9		
0.9-1	47	33.6		
>1	1	.7		
Total	140	100.0		

### Cropping system

As suggested by Table 8, the major crops grown in the area are barely wheat, bean, *teff*, pea, and maize. Traditionally, in the study significant, the major cereals grown by most of the farmers are barely wheat or bean, which accounts for 30.7%, 23.6%, and 16.4%, respectively. By referring to Table 8, we can conclude that the area is a temperate zone.

The most common feature of the cropping systems in the study area is crop rotation, which is practiced widely. Crop rotation is done by growing two or three different crops on the same field, one after the other and within a time frame of a year or two or three years, repeating this rotation over and over again. In the agricultural sense, this is practiced to help the soil recover after growing one crop, and if fallow is used in the turns instead of a plant, it does so even more.

As we can see from Table 9, about 24% of the respondents reported that they practice changing to another crop each year. Meanwhile, the rest of the respondents said that they did switch to other crops and fallow (16.3%), practice fallow (9.3%), and plant the same crop each year (6.4%). Out of interviewed farmers, 43.7% of the respondents practiced intercropping. Intercropping, mainly utilizing legumes, is a deliberate measure to maintain soil fertility. For example, in all *kebeles*, intercropping always involves incorporating a legume, such as a bean, along with other crops. Legumes emphasize enhancing soil fertility since inorganic fertilizer use has fallen drastically because of the high prices. To practice such a system, different crops are intercropped, including maize + bean, maize + potato, maize + cabbage, and bean + potatoes mainly are mostly two practical advantages of the intercropping system: mixing legumes with a grain crop, especially maize. Firstly, legumes are nitrogen-fixing plants; therefore, by intercropping the two, farmers do not even have to apply fertilizer or reduce it since most of them cannot afford to buy fertilizer. Lastly, legumes are a cover crop, so they suppress the growth of weeds and minimize the problematic task of weeding.

**Figure 2.** Degraded land in Albuko Woreda, South Wollo, Amhara, Ethiopia**Table 8.** Major crops are grown in order of importance by the farmers in Albuko Woreda, Ethiopia

Types of major crops grown in order of importance	Frequency	Percent
Barely	43	30.7
Wheat	33	23.6
Bean	23	16.4
Teff	17	12.1
Pea	13	9.3
Maiz	11	7.9
Total	140	100

**Table 9.** Crop rotation practice by the farmers in Albuko Woreda, Ethiopia

Crop rotation practice	Yes		No		Percent	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Intercropping	61	43.7	79	56.3	140	100
Change to other crops each year	34	24.3	106	75.7	140	100
Change to other crops and fallow	23	16.3	117	83.7	140	100
Practice fallow	13	9.3	127	90.7	140	100
Plant same crop each year	9	6.4	131	93.6	140	100

### Major uses of crop residue

As indicated in Table 10, the use of crop residues for livestock feeding was the most common practice in the study area. The Researchers' discussion with farmers and extension agents indicated that crop residue from small cereals (wheat, barley, and *teff*) and legumes (beans and faba bean) are taken from the crop field to the home or villages and stored for animal feed due to high animal feed shortage. In addition, maize and other stalk are mainly used

for fuelwood and fencing, respectively. Animals grazed the leaf and leaf sheath right in the field. This practice shows that soil fertility declines most rapidly in the primary fields because crop residues from these regions are used for livestock feed. In contrast, animal manure is used only to maintain soil fertility.

Another potential measure to reduce soil/nutrient loss is mulching, covering the soil surface with crop residues. Through mulching, the hydraulic force of the raindrop on the soil particle will be reduced. Thus, soil detachment is minimized, but mulch is not applicable in the study villages' farming systems since the farmers use crop residue for different purposes, described in Table 10.

#### *Soil fertility amendment methods*

As shown in Table 11, almost all farmers apply inorganic fertilizer and farmyard manure to improve soil fertility in the study *kebeles*. This could explain the perception that the effect of soil fertility loss is a decrease in crop yields. It also demonstrated the deep concern to achieve better returns. Table 11 shows that soil fertility measures are being practiced. As we can depict from Table 11, about one hundred percent of the interviewed farmers used farmyard manure, but only to maintain soil fertility of homestead gardens in all study *kebeles*. The primary land-use systems in the community include homestead farms, where the most important crops such as wheat, *teff*, barley, and vegetables are grown.

#### **Inorganic fertilizer**

All of the interviewed farmers used chemical fertilizer as the sole source of improving soil fertility of outer fields where cereal and pulse crops are grown, as is depicted in Table 11. Significantly few farmers tended to use a combination of organic and inorganic fertilizers instead of purely relying on inorganic fertilizers, as was more familiar with the majority of farmers.

**Table 10.** Uses of crop residue by the farmers in Albuko *Woreda*, Ethiopia

Uses of crop residue	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Animal feed	140	100	00	0	140	100
Fuelwood	140	100	00	0	140	100
Fencing	63	45	77	55	140	100
Burn	33	23.6	107	76.4	140	100
Other uses	5	3.6	135	96.4	140	100

**Table 11.** Soil fertility measures being practiced in Albuko *Woreda*, Ethiopia

Practices	Practiced		Percent		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Use of farmyard manure	140	100	00	0	140	100
Use of inorganic fertilizer	140	100	00	0	140	100
Crop rotation	107	76.4	33	23.6	140	100
Intercropping	75	53.6	65	46.4	140	100
Agroforestry	63	45	77	55	140	100
Use of compost and mulch	57	40.7	83	59.3	140	100

Through discussion with local extension agents and farmers, we proved that the progressive increment of fertilizer cost after subsidies were being phased out was a major bottleneck to use an equal amount of fertilizer as farmers had before. However, in small-scale farming systems like the study area, where inorganic fertilizers are too expensive and unaffordable, the combined application of organic fertilizers with a small number of mineral fertilizers was found to be the promising route to improve the efficiency of mineral fertilizers and to achieve higher yields in smallholder farms. Long-term trials conducted in Kenya on organic and mineral fertilizer interaction also showed that maize grain yield was consistently top for 20 years in plots fertilized with mineral NP combined with farmyard manure than plots with sole mineral NP or farmyard manure (Palm et al. 1997).

One potential source of organic fertilizer is farmyard manure. Fortunately, in all *kebeles*, the availability of cow dung is much better than the abundant firewood found in the study area. However, as indicated above, farmers were not using manure for soil fertility replenishment of crop fields. The reason could be partly due to the lack of relevant knowledge regarding the combination of judicious use of mineral fertilizers and improved organic residue management via composting and application of farmyard manure.

Improving the content of organic matter of crop fields is very crucial to slow down the present trend of land degradation and the accompanied low productivity. Farmyard manure has a long residual effect and does not have to be applied every year. Farmyard manure could help trap the chemical fertilizer and make it more useful. Hence, increasing the supply of farmyard manure is a viable option in restoring soil fertility and enhancing soil organic matter among smallholders in the study area. Increased organic matter content will improve the efficiency of inorganic fertilizers through increased water availability, reduced nutrient loss from leaching and desertification, and increased microbial activity (Palm et al., 1997).

#### *Agroforestry*

As we can see from Table 11, one can conclude that the findings of this study also suggest that agroforestry is partially used as a means of maintaining soil fertility in the study area. In the study *kebeles*, scattered trees on cropland are also found, but the trees are widely spaced and probably have little effect on soil fertility maintenance. Agroforestry could play a potentially valuable role in enhancing soil organic matter and improving land productivity (Shibru 2010).

Soil organic matter helps retain essential nutrients, improves infiltration and water-holding capacity, and reduces erosion. Even when inorganic fertilizer is available, a minimum amount of organic matter is required for its efficient use. Given that external inputs may continue to be unaffordable, agroforestry could be useful in maintaining soil fertility. But further investigation is merited to establish agroforestry as a profitable investment and the best alternative for the sustainable increase of land productivity (Shibru 2010).

### Livestock production

The type and the total number of livestock owned across all sample households are given in Table 12. Sample farmers rear livestock for various purposes, including draught power, milk, meat, eggs, transport, and other objectives. The primary feed sources for livestock in the study area include straw, grazing land, and maize stalk during its vegetative stage.

Livestock is an integral part of the farming system. As one can see from Table 12, every household has an ox, 2 sheep, and 2 chickens per head. In all *kebeles*, cattle are as much important. Oxen provide the significant power needed for farming. Sheep, goats, and poultry are substantial sources of cash and food. The few horses, mules, and donkeys available give the service of locomotives to transport goods and people.

Ownership of the livestock is also used to measure the wealth status of households. Hence the social stigma is attached to the number of animals owned regardless of economic value and the feed shortage.

As shown in Table 13, none of the respondents have their private grazing land. However, all respondents have communal grazing land for their livestock. The reason for not having hay as their animal feed is that they prefer selling it and replacing it by buying the cheap type of animal feed to have lots of amount in feeding their livestock. As many as 37% of the respondents reported not using hay as their animal feed. Instead, crop residue is the most popular animal feed.

There is also a severe shortage of on-farm grazing land. For example, 71% of sampled households reported that grazing areas on their farm were decreasing because of farmland expansion. Respondents (68%) reported that grazing land was needed for increased crop production and tree planting. In contrast, the rest of the respondents (5.9%) said decreasing their grazing land for their house construction, and 9% did not know the actual cause (Table 14).

Despite the chronic feed shortages and grazing land scarcity, few farmers reported the adoption of more intensive methods of fodder production. This situation indicates the need for an active extension service to improve the current livestock management system. Cash income for household financial requirements is mainly generated from the sale of livestock and crop products. A limited number of households make off-farm income. For example, only 13% of all homes surveyed were engaged in off-farm activities. Hence, even though agricultural land is under intense pressure, a lack of alternatives that help to absorb the excess workforce and reduce the burden on the ground would likely worsen the problems of land degradation and nutrient loss on arable land. Also, the lack of non-farm activities can affect land management by the inability to fund the purchase of inputs and investments (Table 15).

### Farmers' perception and attitude towards soil degradation

Farmers' perception of soil erosion as a potential hazard to agricultural production and sustainable agriculture is the most critical determinant of conservation measures. Those farmers who perceive soil erosion as a problem having

adverse impacts on productivity and who expect positive returns from conservation are likely to adopt available conservation technologies (Gebremedhin and Swinton 2003). On the contrary, farmers will not benefit from controlling erosion when they do not acknowledge soil erosion as a problem. They will likely decide against adopting any conservation technologies.

**Table 12.** Type and number of livestock owned by the sample households (N=140) in Albuko *Woreda*, Ethiopia

Types of livestock	No. of animals	Mean
Oxen	157	1.1
Cows	130	0.9
Calves	163	1.2
Heifer	30	0.2
Horses	17	0.1
Mules	13	0.1
Donkeys	19	0.1
Goats	35	0.3
Sheep	223	2
Chicken	273	2

**Table 13.** Source of animal feed in order of importance in Albuko *Woreda*, Ethiopia

Animal feed	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Communal land	140	100	00	00	140	100
Crop residue	140	100	00	00	140	100
Hay	103	73.6	37	26.4	140	100
Private grazing land	00	00	140	100	140	100
Other	97	69.3	43	30.7	140	100

**Table 14.** Trend of animal feed in Albuko *Woreda*, Ethiopia

Trend	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Increasing	00	00	140	00	140	100
Decreasing by farmland expansion	99	71	41	29	140	100
Decreasing by both crop production and tree planting	88	62.8	52	37.2	140	100
Decreasing by housing	8	5.9	132	94.1	140	100
Do not know	13	9	127	91	140	100

**Table 15.** Livelihood of farmers in Albuko *Woreda*, Ethiopia

Livelihood	Yes		No		Total	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Off-farm activities	18	13	122	87	140	100
Sale of crop products	111	79.3	29	20.7	140	100
Sale of livestock	117	83.6	23	16.4	140	100
Both crop and livestock sale	8	5.9	132	94.1	140	100
Others	13	9	127	91	140	100

As shown in Table 16, only 35% of the sample farmers believed that overgrazing was the most severe cause of soil erosion, followed by 27% of the farmers who considered that deforestation caused the most erosion. Based on the result, we can say that overgrazing and deforestation are the most severe problems that can cause soil erosion in the selected study area. We only found that 17% of cultivation of steeply sloping land was the other cause that could challenge the loss of soil. Sixteen percent of the respondents answered that excess rainfall is the primary cause of soil degradation; in contrast, other respondents said that poor agricultural practices (15%), poor government policies (14%), and over-cultivation (13%) are the leading causes of soil degradation, respectively.

*Chi-square tests on the effect of erosion on productivity (land suitability criteria by soil loss rate, soil fertility, and potential crop yield)*

Concerning farmers' knowledge of land productivity and how it was affected by erosion, the sample respondents were questioned on what criteria they used to conserve and depict the type of suitable soils. So, to handle such an issue, a discussion with key informants was made and proved that farmers in the study area divided their land into several plots for various purposes. The farmer separates fields based on different critical criteria. For this study, three land suitability criteria were considered, i.e., soil fertility level, soil loss status, and crop yield production potential. In the study area, most field holdings tended to stretch from the very steep hill slope to gentle slope segments. Thereby, farmers were able to express their perceptions of each slope position.

The above result (Table 17) rejects the null hypothesis, suggesting that no causal relationship between land suitability and soil loss rate is denied based on the above chi-square test result. Ninety-five percent of the observed data proves a significant relationship between land suitability and soil loss rate in a 5% degree of error interval. The result indicates that land suitability dramatically affects soil fertility rates. Consequently, this result is congruent with what farmers knew about the speed of soil loss and level of slope position as positively related, suggesting that the level of soil loss rate is more significant when the slope of the land is very steep.

By examining the cross-tabulation of land suitability and soil fertility (Table 18), we reject the null hypothesis that suggests that land suitability does not affect soil fertility rate. However, the chi-square test proves otherwise. It means that land suitability dramatically changes the soil fertility rate. The chi-square test result shows that land suitability affects soil fertility by about 95%. This means, in a typical distributed data, the precision is 95% in a 5% error range. Therefore, this result is congruent with what farmers knew about the rate of soil loss and level of slope position as positively related. The finding suggests that the level of soil loss rate is very high when the slope of the land is very steep.

The cross-tabulation result of land suitability and crop yield (Table 19) rejects the null hypothesis, suggesting that land suitability does not affect crop yield. However, the

chi-square test proves otherwise. This is to mean that land suitability dramatically changes crop yield. To make it clear, the chi-square test result shows that land suitability affects crop yield by about 95%. This means, in a typical distributed data, the precision is 95% in a 5% error range. Therefore, this result is congruent with what farmers knew about the rate of crop yield and level of slope position as inversely related. This suggests that the level of crop yield rate is shallow when the slope of the land is very steep.

**Table 16.** The perceived major causes of soil erosion and their ranks in Albuko Woreda, Ethiopia

Rank	Causes of soil degradation							Others
	Defores- tation	Over grazing	Over culti- vation	Agro poor practi- ces	Steep slope culti- vation	Excess rainfall	Poor poli- cies	
1st	27	35	13	15	19	16	14	3
2nd	8	9	45	26	31	18	3	0
3rd	31	12	17	27	23	19	11	0
4th	15	46	22	26	12	13	6	0
5th	19	11	15	26	17	35	12	5
6th	17	10	17	16	32	20	28	0
7th	23	17	8	4	8	19	33	28
8th	0	0	3	0	0	0	33	104
Total	140	140	140	140	140	140	140	140

**Table 17.** Chi-square analysis of land suitability by the soil loss rate

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.532a	2	.465
Likelihood Ratio	1.561	2	.458
Linear-by-Linear Association	.625	1	.429
N of Valid Cases	140		

Note. cells (.0%) have expected to count less than 5. The minimum expected count is 10.54.

**Table 18.** Chi-square analysis of land suitability criteria by soil fertility

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.911 <sup>a</sup>	2	.141
Likelihood Ratio	4.312	2	.116
Linear-by-Linear Association	2.721	1	.099
N of Valid Cases	140		

Note: 2 cells (33.3%) have an expected count of less than 5. The minimum expected count is 4.64.

**Table 19.** Chi-Square analysis of land suitability criteria by crop yield

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.282 <sup>a</sup>	2	.319
Likelihood Ratio	2.447	2	.294
Linear-by-Linear Association	1.689	1	.194
N of Valid Cases	140		

Note: 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.21.

The majority of farmers perceived that steep and very-steep slopes were landscape segments with a high risk of soil erosion and low soil fertility level, causing low crop yields. Gentle slopes ranked reasonably, showing moderate yield potential. The farmers' description aligns with scientific knowledge that acknowledges the effects of slope steepness on land productivity. Other scientific experiments (Rockstöm et al. 1999) agree with farmers' observation. The farmer's knowledge is also aligned with findings by Steiner (1998) on farmers in Rwanda who associated soil suitability with slope position. Steeper slopes had shallower soils, whereas fine-textured soils dominated plateau and foot slopes, implying high fertility soils.

### Soil and water conservation practices

In many parts of Ethiopia, farmers use native soil and water conservation practices as integral to their farming systems. Farmers have developed methods that have maintained productivity and contributed to long-term sustainability, while introduced measures have often been rejected or failed to achieve their technical objectives. Farmers have their criteria to evaluate the efficiency of soil water conservation measures. Their standards are often based on the quality of the natural resources (farmers are more likely to preserve those soils that will give the highest return on their investment), gender, the resource level of the household (particularly income levels and labor availability), education, cropping intensity as well as cultural traditions related to age. However, of great importance is the need to maintain or increase soil productivity.

The field survey results shown in Table 20 suggest that most of the farmers' indigenous knowledge recognized soil erosion problems and were willing to give their opinion about the conservation practice.

Drainage ditches, also known as traditional ditches, are widely used soil water conservation practices in the study area. Microchannels are constructed on cultivated farms to drain excess water and control soil erosion. Out of the total respondents, 20% applied indigenous drainage ditches. These are low-cost measures in which construction is part of the regular plowing activity. However, unlike the plow furrows, the ditches are made broader and deeper in dimension and usually run diagonally across the field. Farmers in the study area call the drainage ditches "Feses."

**Table 20.** Indigenous knowledge in soil water conservation in Albuko Woreda, Ethiopia

Indigenous knowledge	Freq.	Percent	Valid Percent	Cumulative Percent
Traditional ditches 'feses.'	28	20.0	20.0	20.0
Application of manure	17	12.1	12.1	32.1
Soil (stone) bund	29	20.7	20.7	52.9
Traditional cut-off drain 'makor.'	11	7.9	7.9	60.7
Planting tree	18	12.9	12.9	73.6
Contour ploughing (curved plough)	25	17.9	17.9	91.4
Other	12	8.6	8.6	100.0
Total	140	100.0	100.0	

The application of manure in the study area is used by some farmers (12.1%) to improve the fertility of the soil. The best form of organic fertilizer is manure Soil and water conservation management consisting of animal dung and urine. Farmers used manure mainly near the homestead. During the focus group discussions with the key informants and DAs (Development Agents at *kebele* level), farmers (primarily those who were poor) have increased the use of manure because of the high current price of inorganic fertilizers.

Soil (stone) bund is a dam or ridge built across a slope along the contour. Soil bunds are made of soil or mud. The farmers construct the soil bunds for erosion control on moderately sloping areas. On steep eroded bare lands, stone terraces are the most used structures in the study area. As critical informants state during the interview session, the stone terraces are considered useful in erosion control in steep areas. From the survey, 20.7% of the respondents have constructed soil and stone bunds in the common eroded lands, particularly around the mountainous region; farmers were constructing bunds motivated by the cash they could earn from a safety net program.

Traditional cut-off drains become physical structures constructed by digging the soil deep to divert the runoff before reaching the farmland. The survey results show that 7.9% of the respondents used to cut off drains. The farmers construct such structures to prevent loss of seeds, fertilizer, and soil due to excessive runoff coming from uplands and dispose of the excess water for the field. However, according to farmers' opinions, most of these structures accelerate soil erosion over time.

Planting trees and other non-crop plants such as sisal euphorbia and eucalyptus are sometimes planted along the contour with other conservation practices. This type of conservation method is applied by 12.9% of the respondents to reduce runoff and conserve the soil and water around the plants' roots. Indigenous and newly introduced trees and shrubs are planted on overused eroded lands to make the land fully productive again. In specific areas, common highly degraded grounds are closed off to livestock to protect from grazing and planted with trees for regeneration.

Contour ploughing is tilling the land along the slope's contours to reduce the runoff on the steeply sloping ground. It is used separately or combined with other conservation structures such as cut-off drains and plantation trees. From the sample farmers, 17.9% applied the composition in combination with cut-off waste; it is carried out using the ox-drawn plough. Hence, it is part of the standard farming activity; it needs no extra labor and time for construction. According to Mulat (2013), in several cases, most farmers in Ethiopia apply this method for soil conservation. The rest of 8.6% of respondents said they used different traditional techniques to prevent soil and water degradation. Teklu and Gezahegn (2003) argue that fallowing is abandoning the land for rejuvenation when the nutrients are exhausted. It is one of the traditional methods of leaving the cropland uncultivated for one or more years to recover soil fertility and minimize soil loss. In the study

area, some of the respondents said that fallowing is used when the farmland is unproductive and loses its fertility.

Leaving the crop's residues on the field after harvest is another traditional practice used by the farmers in the area. The survey result shows that some farmers are implementing this measure to improve soil fertility and protect the land from erosion. For Teklu and Gezahegn (2003), after legumes or oil crops, the significant cereals are rotated mainly for soil fertility maintenance, disease control, and weed. Crop rotation becomes another widespread phenomenon where maize, groundnut, and bean are grown rotationally. The farmers apply crop rotation for different reasons, such as soil fertility, therefore, improved crop yield. As the scientific method developed, the farmers knew that alternating high residue-producing crops could achieve soil fertility with the low growing residue-producing crops.

Mixed cropping is widely practiced in the area. Farmers inter-plant two or more crops together with some root edible plants. The vast majority of the cases are a mix of maize and groundnuts. Mixed cropping in the area helped reduce erosion by having a crop on the land for a more extended year period. Also, it served to cultivate different crops on a single farmland period. However, the crops in the area have broadly similar growing seasons. Nevertheless, cereal crops may benefit from including leguminous plants to improve their nitrogen fixation.

Most farmers use surface mulches in their fields that provide a protective cover when crop cover does not exist. The benefit of protective covering has been widely appreciated, as was the improved infiltration rate managed by the approach and decreased evaporation rate. The further stated objective is the addition of nutrients to the soil by decomposition of the organic matter. However, the density of mulch in many fields was below the level required to be most effective as protective cover since the use of the residue as animal food was witnessed in many households of the area.

#### **Problems related to soil water conservation measures**

The respondents' significant issues related to conservation structures include a source of pests, inconveniency during ox ploughing, reduction of farmland, labor intensiveness, difficulty in implementation, and costliness. During the field survey, it was recorded that out of 140 respondents, about 39.7% indicated that soil (stone) bunds reduce farmlands, 35.8% responded inconveniency during oxen ploughing, while 24.5% revealed labor-intensive.

Regarding cut-off drains, 41.7% of respondents reported problems of costly, 34.6% said implementation difficulty, and 23.7% expressed labor intensiveness. Concerning waterways, 39.2% of the respondents indicated that it is expensive, 35.5% suggested it is difficult to implement, and 25.3% said it is labor-intensive. Respondents were also asked to compare the improved conservation practices with the traditional ones. Around 70% of the respondents indicated that conventional conservation practices better retain soil.

#### **Conclusions**

The fast population growth on the finite land resources continuously makes it difficult for developing countries to produce enough to feed their population. Attempt to generate often enough relied on the horizontal expansion of agricultural practices with substantial irreversible ecological degradations stemming from deforestation, overgrazing, and soil erosion. This scenario has culminated in poor land productivity with adverse economic, social, and political implications. Agricultural development in Ethiopia is hampered by land degradation; degradation, in turn, is threatening the overall sustainability of agricultural production. Soil erosion is a significant cause of land degradation in Ethiopia.

The Indigenous knowledge system is essential to maintain the present-day diverse and rich biodiversity among the estimated 80 ethnic groups under different agro-ecosystems in both the highland and lowland against Ethiopia's historical social and natural problems. Past research shows the role of indigenous knowledge in sustaining ecosystems while addressing socio-economic and environmental issues.

Despite the importance of the knowledge as shown by ethnoecology research, which started in the 1980s, the effort to integrate the experience with land development is not in-place. Previous research shows its importance in addressing soil infertility, labor, bio-diversity, land shortage, and increasing agricultural productivity to the extent of showing its importance in livelihood adaptation and climate change. Although modern technology is a challenge for the farmers, they have a good practice in handling soil and water by the different indigenous knowledge they employ (Table 20). Except for native terracing and soil and water conservation measures, a past study has not examined the spatial variation of practices in Ethiopia. Previous research has focused on farmers' attitudes, characterizing, and the role of the practices.

Based on the result of this study, out of the total respondents, 20% applied indigenous drainage ditches. Whereas 20.7% of the respondents have constructed soil and stone bunds in the common eroded lands, especially around the mountainous area, farmers were constructing bunds because of the cash they would earn from a safety net program. On the contrary, personal factors, socioeconomic factors and livestock holding capacity of household, institutional factors, biophysical factors, and degree of slope affect the probability of adopting both improved and traditional soil and water conservation measures.

Land availability often influences farming practices and hence affects the land degradation process. All the farmers cultivated their land with no room for expansion except in marginal areas. Sloppy grounds, which used to be grazing areas or tree plots, became under cultivation. Other alternatives that can reduce the pressure on the environment and provide a livelihood for farmers include non-farm employment.

Most farmers experienced soil erosion, a phenomenon related to the widespread onsite erosion indicators. They have sufficient knowledge of the water and soil

conservation processes and the consequent on-site erosion impacts. They clearly understand various erosion indicators spread over the landscape and which adversely affect their soils. Rill and gully were most often mentioned indicators, followed by sheet wash (runoff flow paths), root exposure, and appearance of gravels in large proportion on croplands. They attributed the formation of these indicators to factors such as high rainfall, runoff from upslope fields, steep slopes, and poorly designed or ineffective soil water conservation measures, which they find themselves incapable of changing.

Farmers understand the harmful effects of erosion on crop productivity. They refer soil fertility levels and crop yield potential to a slope position. Fields on flat and gentle slopes were recognized to have the highest potential for crop production. Fields located on steep and very steep slopes were seen to be eroded hence the likelihood of not realizing high crop yields.

Likewise, farmers use a variety of indicators to understand and explain the condition of their land fertility. Farmers mentioned signs used to perceive and understand soil fertility decline identified by this study. Those signs include reduction of crop yield, stunted growth, change in crop color or crop leaves, crops unable to cope with weed dominance, high amount of straw yield compared to crop yield, and disappearance of grass and some local specific plant species. However, some of the biological and physical indicators are local and site-specific. Regarding indicators of soil fertility decline, there is an appreciable indigenous knowledge that can be tapped in developing plant species indicators.

Farmers perceived that increased crop yield could be realized, among other husbandry practices, by implementing soil water conservation measures. In addition to increased crop yield, soil water conservation measures improved soil fertility and soil-water retention. Farmers were knowledgeable about various soil water conservation rules, but few implemented them. Ridges, water diversion ditch, and contour ploughing were the most popular and traditional soil water conservation practices. Low appreciation of the agroforestry systems in the research area as a soil conservation measure suggests that farmers were more interested in the tree by-products (construction timber and wood fuel) than its scientifically perceived influence on soil and water conservation. Although farmers knew many soil water conservation measures, constraints to ensure widespread adoption were still experienced.

The most significant constraints to adopting soil water conservation were decreased farm size and inconvenience during farm operations, especially for free movement of oxen plough, followed by lack of capital and tools, labor shortage, and construction know-how.

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