Farmers' Knowledge on Soil Conservation Technologies, Associated Farm and Farmers' Attributes in Hilly Farms of Nandi County, Kenya

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Original Research Article

ABSTRACT

Soil erosion is an issue of global concern due to its effects on the natural resource base in which agriculture is based on. In Kenya, low utilisation of soil conservation technologies (SCTs) has been blamed for continued land degradation. A study was designed to examine association of selected farmers' and farm attributes with knowledge on SCTs using an ex post facto survey design. A sample of 138 farmers was accessed in the hilly terrains of Nandi County, Kenya through a multi-stage sampling technique. The study was based on the trans-theoretical model and its stages of change, with a focus on its initial stages. Data was questionnaire-based and the data was analysed for associations using Gamma and Sommers' delta. Kruskal-wallis (KW) test was utilised to test for differences between groups. Post hoc tests are based on Bonferroni correction. Results indicate that there was significant influence of formal education levels, gender, duration of residence and farmers income levels on knowledge in SCTs. Significant KW test results on differences in knowledge levels on SCTs were; Education, $H(2) = 9.359$, $P= 0.009$; Age, $H(3) = 9.938$, $P=.019$; Gender, $H(1) = 3.429$, $P = .064$; duration in current farm, $H(2) = 6.122$, $P = .047$ and income levels, $H(2) = 8.710$, $P = 0.013$. There were no significant differences based on household size, farm gradient and farm size. Information literacy on SCTs was low among lowly-educated and low-

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income categories. Deliberate investments in soil conservation measures targeting these categories are recommended. An in-depth study on the underlying causes for the face-value association is recommended.

ABBREVIATION

SCT : Soil Conservation Technology

1. INTRODUCTION

Soil erosion problem is an issue of global concern due to its effects on the natural resource base in which agriculture is based on. Losses of about 62 tons of soil per ha per year in shallowly cultivated sandy loam soils receiving an annual rainfall of 620 mm with an erosivity of 330 mm have been reported [1]. The sediments lost during the transportation had an average of 0.59% organic matter while the parent soil where it was being carried from had 0.26%, suggesting that the transported sediments were about twice richer in organic matter compared to the average soil conditions. Transported sediments also carry away Potassium, Nitrogen, Phosphorous and other soil nutrients [1]. As the soil erosion progresses over time, it leads to exposure of a less fertile layer and the land becomes unproductive (Ibid). This process of continued soil erosion is particularly more severe in steep slopes.

To counteract the harmful effects of soil erosion, soil conservation measures have to be employed to reduce the flow of water and to conserve the soils. Runoff water destabilizes the soil and may make it completely eroded, exposing rock surfaces and making the land agriculturally unproductive [2]. The overall goal of any soil conservation measure is to reduce the proportion of precipitation that runs-off over the soil surface by reducing the rate of movement and increasing infiltration [3]. Soil conservation technologies should keep the surface of the soil in a condition that water will enter it freely (Ibid). When rain strikes a soil, it will either infiltrate or be retained on the surface or flow off [2]. The author argues that a soil surface with uneven micro-relief can store a considerable amount of water in the small depressions and allow for more infiltration. In steep slopes, however, a considerable amount of water will flow off. This observation implies that there is a greater need for soil conservation technologies to improve infiltration in steep cultivated lands.

In Kenya, low utilization of soil conservation technologies and unsustainable agricultural activities has been blamed for land degradation [4]. The situation is exacerbated by the clearing of forested areas for agricultural production [5]. The ministry of agriculture's strategic plan for 2008-2012 recognised that some parts of the country continued to experience soil loss of over 100 tonnes per ha per year in spite of previous interventions through the agricultural extension system [6]. In many cases, severe soil erosion in hilly terrains results in mudslides as observed on one occasion during a field visit to the study area (Plate 1). This paper focuses on the knowledge in soil conservation technologies that the farming communities have in stock. Why? Poor management of resources such as cultivation in steep slopes and unnecessary clearing of more land for cultivation when the current cropped land is not productive enough is thought to be related to the farmers' level of awareness.

This study is based on the trans-theoretical model (TTM) and its five stages towards adoption of technologies. The trans-theoretical model was first advanced by Prochaska and others in the 1970s [7].The current study focuses, in particular on the first stage. The trans- theoretical model or the stages of change theory conceives behaviour change as occurring in five stages. The first stage in behaviour change is awareness [8]. The other stages in the stages-of-change theory are contemplation stage, preparation stage, decision stage and the action stage. The action stage can be regarded as an adoption stage. The final stage according to the trans-theoretical or stages-of-change model is the maintenance stage [8]. Back to the first stage; at the awareness stage, which is also referred to as the pre-contemplation stage, the farmer is still raising awareness about the benefits of change (Ibid). At this stage, it can be argued that there is a need for a stock of knowledge on an agricultural technology before it can proceed through to the other stages and ultimately to the implementation or adoption stages.

Plate 1. Effects of soil erosion in a hilly terrain, Tindiret ward, Nandi, Kenya
Source: Field observation, 26th May, 2020

Knowledge on an innovation can influence the intention to act [9]. Knowledge can similarly influence the ability to formulate strong arguments for the need to adopt. Farmers' knowledge regarding soil conservation technologies can greatly influence the process of adoption and practice (Ibid). The intention to adopt a technology has been previously linked to the level of knowledge or awareness. It has been argued that knowledge can modify the links between attitudes and actions [9]. According to [10], individuals at the pre-contemplation stage do not know that the technology exists or know a little and tend to avoid changing their thinking and behaviour. At the contemplation stage they have the knowledge; they seek more information and form attitudes. The current study relates to the knowledge that smallholder farmers have on soil conservation technologies since this is a prerequisite for progress towards their implementation. In some literature this has been referred to as the intellectual dimension in the process of adoption [11]. Some authors have also explained this as communication behaviours that encompass positive relationships with sources of information such as Agricultural extension agents [12]. It has been emphasized that the ability of individuals to understand their own information-needs and to start seeking for the information is an important aspect in the process of adoption of agricultural technologies [12]. This constitutes information literacy.

This study focuses on the information literacy in soil and water conservation technologies by practicing farmers. The question of concern here is whether socio economic factors have a role in information literacy. Information literacy has been explained by [13] as the ability of an individual to recognize, evaluate and use efficiently the information that he/she needs. Simply put, this is an awareness of written knowledge (Ibid). In the current context it is not only an awareness on written knowledge but is also awareness on knowledge passed on through human interactions, mass media and any other form of transmission. As [14] puts it, managing information input is going to be very crucial for agriculture in the 21st century.

1.1 Purpose

The purpose of the study was to examine the association between selected farmers' and farm attributes with the farmers' knowledge on soil conservation technologies. The farmers' attributes; age, level of formal education, household size and gender were investigated for their influence on farmers' knowledge in soil conservation technologies. The farm attributes; farm size and farm income were also assessed for potential influence on the knowledge of the farmer. How were the attributes measured?

The independent variables in the study were measured on categorical scales. The chronological age of the respondents was categorized into four groups, formal education three groups, household size four groups and

gender two groups. Farm size and farm income were each categorized into three groups. The dependent variable was measured on a 5-point Likert-type scale based on the respondents' self-reported level of knowledge on soil conservation technologies; from very low to very high.

2. METHODOLOGY

2.1 Study Site

Tinderet Sub County in Nandi was purposively selected to investigate the farmers' and farm attributes for potential links with knowledge in soil conservation technologies. Nandi County is located in the rift valley region of Kenya and occupies an area of about 2884 km^2. It is located at the longitude 35^{0}25'E and latitude 0^{0}34' N [15] in the western part of Kenya (Fig. 1). The county receives an annual rainfall that ranges between 1200 and 2000 mm per annum with the Northern parts receiving the lower average. The rainfall amounts and intensity in this county has implications on soil conservation practices. The rainfall intensity is closely associated with rainfall erosivity. About 12% of the total land area in the study area is covered by forests and most parts of the county experience mean temperatures of between 18^{0}C and 22^{0}C. A few areas in the lowland areas experience temperatures as high as 26^{0}C [16].

Tindiret Sub County which has diverse agro ecological zones and undulating terrain was deliberately chosen for the current study. The Sub County produces a wide range of agricultural produce, with maize and beans as the dominant food crops. Sugarcane is produced as a major cash crop in the lowlands; coffee dominates in mid altitudes and tea in the lower highland zones [15]. The area, however, has an undulating topography and hilly terrains that are prone to soil erosion problems [15]. The soils on the footsteps of the hills were developed from basic igneous rocks and include Nito-rhodic ferralsols and verti-mollic nitosols [17]. The soils have a naturally moderate to high soil fertility, but the soil depths are shallow along the steep slopes [16]. The shallow depths along the steep slopes have implications for water runoff and soil erosion challenges, particularly in cultivated areas where maize, beans, horticultural crops and coffee are produced. These prevailing physiographic and edaphic factors coupled with the relatively high precipitation suggest that farmers in these localities need to be adequately equipped with knowledge in soil conservation. But, what attributes are likely to influence their knowledge levels? This was the focus of this study.

Tinderet Sub County (Study area)
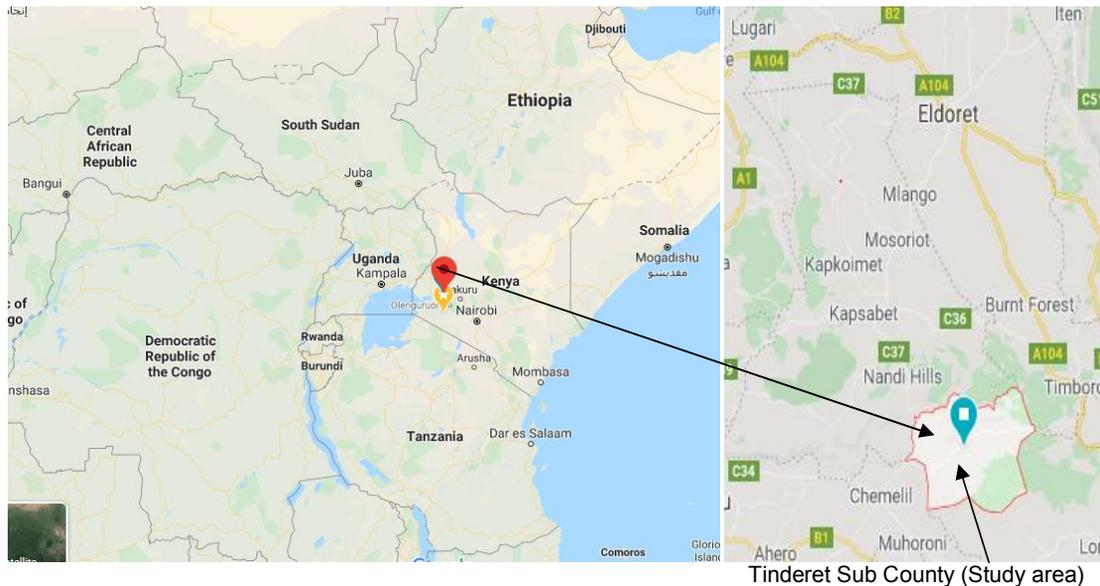
Fig. 1. Map showing location of Tinderet Sub County, Nandi County, Kenya
Source: Google maps

2.2 Study Design

This study broadly adopted a survey design where the investigator is expected to examine the phenomena which exist in a population independent of their own action [18]. The survey study was structured to collect and analyze data by specifically using an ex post facto survey design. It was an appropriate design to facilitate the collection of data from occurrences that have taken place. The ex post facto design has the advantage of providing data from interventions or occurrences from the past that can be analyzed for interaction with other variables as currently observed [19]. In the design, the independent variables are studied in retrospect for possible relationships with presumed dependent variables as currently observed. This suggests that the design attempts to answer the question of whether what we observe presently is related to variables that existed before. Naturally occurring circumstances such as gender, literacy, incomes and other socio economic characteristics of a population can constitute independent variables that have occurred in the past or have been there anyway.

2.3 Data Collection

A sample of farmers to participate in the study was obtained from six catchment areas in the sub county. The catchment areas served as natural strata for a multi-stage sampling procedure that was used to select the participants. From the twelve catchment areas in the sub county, six were randomly selected for the study. From these six primary sampling units or selected catchment areas which had an estimated population of about 300 households, half of the households were randomly selected to participate in the study in a second stage sampling. By the end of the survey period, a total of 138 households had been reached, constituting about 92% of the intended 150 households. Personal and farm data were collected from the sampled farmers using enumerator-administered questionnaires.

2.4 Data Analysis

The data collected were analyzed using descriptive and nonparametric inferential statistics. Parametric tests could not be used in the current study since variables were measured on an ordinal scale and a test for normality using the one-sample Kormogorov-Smirnov test confirmed non-normality (P < .05). The associations between attributes were tested using Gamma and Delta coefficients; both based on chi square analysis. Gamma is a robust test for ordinal data, while Somers' Delta has the advantage of indicating degree of dependency between variables [20]. The distribution levels of knowledge on soil conservation technologies across categories of farmers and farm attributes were tested using Kruskal-Wallis test at 5% significance level. The analysis was carried out to test for differences in mean ranks between categories created based on the farmers and farm attributes. Whereas the Kruskal-Wallis test is analogous to the one way Analysis of variance (ANOVA), unlike ANOVA, it does not require the assumption of normality or same standard deviations in the sample data [18;21]. The Kruskal-Wallis test is based on H statistic which is worked out from the formula;

$H = [\frac{12}{n(n+1)} \sum \frac{Ri^2}{ni}]$ -3(n+1) where n = Sample size, R_i = Sum of the ranks in the ith sample, n$_i$ = Size of the ith sample

The Kruskal-Wallis test uses the ranks of the data to test whether samples have been drawn from the same distribution [22]. The statistic used in the test does not require that the data be measured at an interval or ratio scale (Ibid). The current data on farmers' levels of knowledge on soil conservation technologies was measured on an ordinal level scale and therefore the Kruskal-Wallis test was deemed appropriate for the test for differences between the groups of farmers' and farm characteristics.

3. RESULTS AND DISCUSSION

3.1 Socioeconomic Characteristics of the Participants

Based on the level of formal education, the respondents could be categorised into 10.1% with post secondary education, 18.8% with secondary, 65.2 % with primary level education and 5.8% without formal education. On the basis of gender, 87 % of the households were male headed and 13% female headed. Household sizes ranged from less than 3 members (10.1%) to 4-6 members (40.6%), 7-10 (33.3%) and 10 and above (15.9 %). On the basis of age; 13% of the respondents were aged less than 35 years, 23.2% aged 36-45 years, 31.9% aged 46-55 and 31.9% aged over 55 years. The self-assessment of the study participants on their level of knowledge in soil conservation technologies is as presented in Table 1.

Table 1. Knowledge levels on soil conservation technologies as reported by respondents

Level of Knowledge on SCT		Frequency	Percent
Level of Knowledge	Very High	2	1.4
	High	22	15.9
	Medium	70	50.7
	Low	42	30.4
	Very Low	2	1.4
	Total	138	100.0

3.2 Farmers Age and Soil Conservation Knowledge

The analysis using Gamma and Somers' delta showed that there was a very weak negative association between farmer's age and knowledge on soil conservation technologies ($G= -0.098$, $D = -0.063$) as captured in Table 2. The measures were based on an ordinal relationship between the two variables; both measured in ascending order. A graphical representation of the mean ranks (Fig. 2), however, suggested there could be significant differences between the age categories and the level of knowledge in soil conservation technologies.

The categorical data on the chronological age of the respondents were further analysed for its possible influence on levels of knowledge using the Kruskal - Wallis test. The test revealed a significant influence of age on the level of knowledge, H (3) = 9.938, P=.019. In order to establish where the differences were, the Kruskal-Wallis with post hoc test based on Bonferroni correction was run. The test results showed that the levels of knowledge were significantly different between the youths aged under 35 years and the 46-55 years age category (P = 0.012). The rest of the age categories were not significantly different (Table 3). This observation suggests that the age category under 35 years may have been more of information-seekers compared to the middle aged category aged 46-55 years .Elsewhere, a study by [23] reported that there was no relationship between farmers' knowledge and age. The current finding suggests there is; possibly attributed to information technology use that is prevalent among the youth compared to the middle aged. Those aged over 55 on the other hand may have been aided by their many years of experience in farming and had similar knowledge levels on SCTs with the youth.
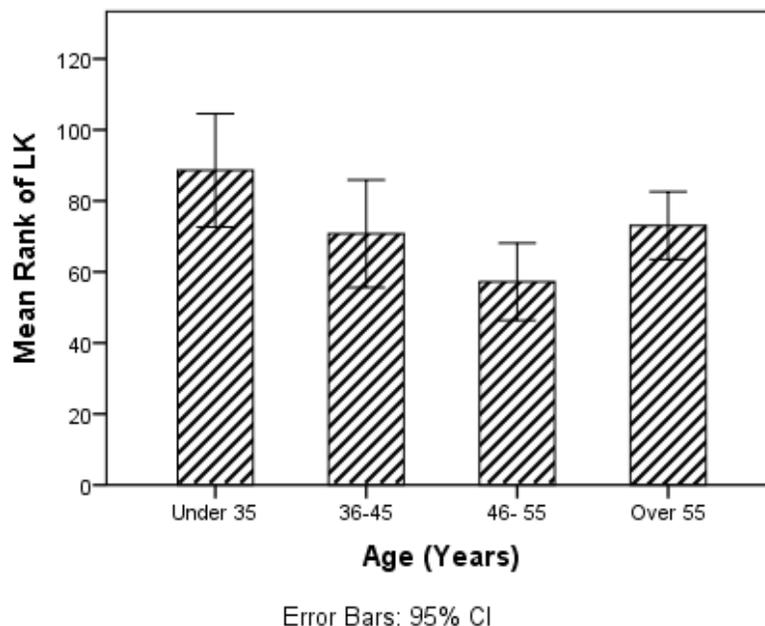
Fig. 2. Mean rank of level of knowledge in soil conservation by age category

3.3 Education Levels and Knowledge on Soil Conservation Technologies

The test for association between farmers level of knowledge on soil conservation and the farmers level of formal education revealed that there was a significant association (P < .05) as measured by Gamma and Somers' Delta coefficients (*G* =0.300, *D* = 0.200) as illustrated in Table 2.The distribution of the level of knowledge on soil conservation technologies was not the same across all categories based on education levels as suggested by Kruskal-Wallis test. There was a significant difference between education levels and awareness as estimated by Kruskal-Wallis *H* statistic, *H* (2) = 9.359, *P* = 0.009.

To establish where the differences were among the education level categories, a post hoc test based on Bonferroni correction was carried out. The test revealed a significant difference between none/primary level category with tertiary level (*P* = 0.006). There was also a significant difference between secondary level category with tertiary (*P* = 0.035). However, there was no difference between none/primary category with the secondary level category (*P* > 0.05).

On a scale of 1 to 5, the mean ranks on the level of knowledge in soil conservation varied as illustrated in Fig. 3. The current finding suggests that formal education is linked to information literacy on soil conservation technologies by practicing farmers. This finding is contrary to a study conducted in Sri Lanka by [23].The study reported that education, among other variables, had shown no relationship with the knowledge level of famers in pest management. The current finding is, however, in tandem with that reported by [24]. The value farmers placed on soil conservation knowledge was reportedly positively influenced by education among other factors in a study conducted in Benue state, Nigeria [24]. Elsewhere in Malaysia, farmers' agricultural productivity attributed to knowledge has also been associated with levels of formal education [25]. The findings in the current study suggest that farmers who have been educated to post secondary levels seek and process information on soil conservation technologies better than farmers at the lower levels in the education ranks. According to [26], being informed about a practice is normally preceded by an ability of the individual to realize the need for the information. The individual then starts seeking the information, evaluates and ultimately uses it. According to the trans-theoretical model, an individual contemplates changes only when one has adequate awareness on the problem at hand. The current finding implies that the more educated farmers were more likely to realize the need for knowledge in soil conservation technologies compared to the lowly educated.
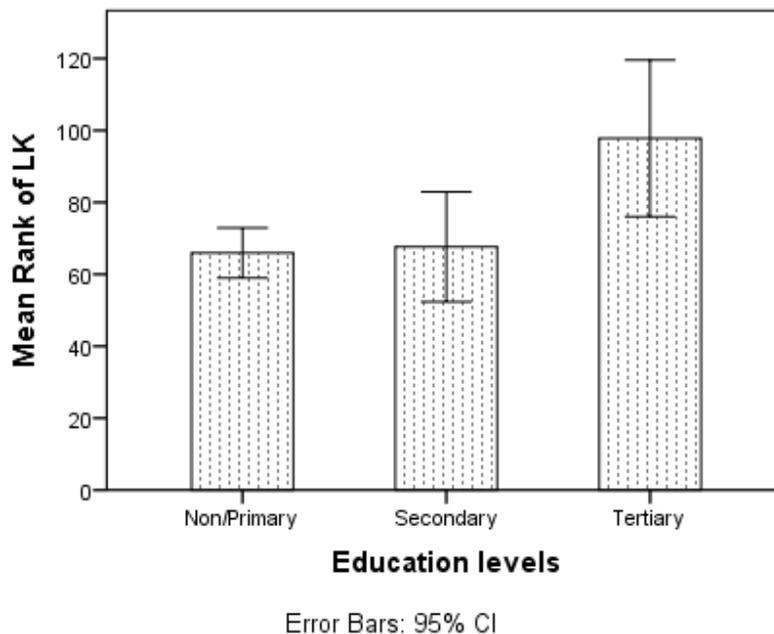

Fig. 3. Mean rank of level of knowledge in soil conservation by education level

3.4 Household Size and Knowledge

There was a negligible association between household size and the farmers' level of knowledge on soil conservation (Table 2). The distribution of the level of knowledge on soil conservation technologies was the same across all categories of household size as measured by *H* statistic (*P* = 0.301). The null hypothesis of no difference across the categories was upheld. A similar study in Sri Lanka on knowledge in pest management did not show any relationship between knowledge in pest management and the farmers' family size [23].

3.5 Duration of Residence in the Farm

There was a moderate strength of negative association between the duration of residence in the same farm and the farmers' level of knowledge on soil conservation technologies (*G* = -0.427, *P*= 0.023 and *D* = -0.282, *P* = 0.023) as summarized in Table 1. A test for variance showed a significant difference between the categories; *H* (2) = 6.122, *P* = .047.

The finding of a fairly strong negative relationship suggests that newly settled farmers appeared to perceive the problem of soil erosion differently. They appeared more inclined to seek knowledge on soil conservation technologies compared to those who had resided in the locality longer. This finding probably means the new-comers perceive the challenge of soil erosion in the hilly terrains better than those who have lived with it for years. This observation has implications for agricultural extension services in providing target-specific soil conservation extension services.

3.6 Gender

The gender of the household head did not significantly influence information literacy based on the independent samples Kruskal-Wallis test at 5% significance level; (*H* (1) = 3.429, *P* = 0.064). However, an analysis using Somers' delta revealed that there was some weak relationship between gender and level of knowledge in soil conservation technologies when gender was treated as an independent variable (*D* = 0.248, *P* = 0.032). This suggests that gender had a role in determining the level of knowledge in soil conservation practice. The observation seems to imply that the female-headed households are disadvantaged in regard

to information literacy on soil conservation technologies.

3.7 Farm Size

A majority of the farmers who participated in the study had parcels of land measuring 1 ha and below (41%), 33% had over 1 ha to 2ha and 26% had over 2 ha. The analysis by cross tabulations showed that farm size had negligible association with knowledge in soil conservation technologies (Table 2). The distribution of level of awareness on soil conservation technologies was also the same across the categories of farm size as tested by the Kruskal-Wallis test (*P* = 0.323). This observation suggests that farm size had no link to the information-seeking behavior of the farm owner.

3.8 Farmers' Income

Significant association existed between the farmers' level of income and the level of knowledge on soil conservation technologies (*G* = 0.352, *D* = 0.224) at 5% significance level (Table 2). There was also a significant difference in the rank distributions between income levels and the level of knowledge; *H* (2) = 8.710, *P* = 0.013. Pair-wise comparisons based on Bonferroni test showed there was no difference between low income category and middle income (*P* > .05). There was also no difference between middle income category and high income (P > 0.05) as summarized in Table 3. So where were the differences? There was a significant difference between low-income category and high income category (*P* = 0.011). This finding suggests that income levels have a role to play in farmers' information literacy on soil conservation technologies. When the ordinal data on levels of knowledge from 1 to 5 were transformed into mean ranks, the mean for low income category was significantly lower than that for high income as illustrated in Fig. 4.

The observation in this study is consistent with a previous finding by [27]. The author reported that farmers who utilised soil conservation technologies had higher income compared to those who did not and suggested that high farm output may have been an incentive for the farmers to seek more knowledge to improve on it. The authors suggested that higher income farmers tended to share more knowledge. In the current study, income was associated with higher levels of knowledge in SCTs, probably because of the associated costs of seeking the knowledge

and evaluating it; a cost which low-income farmers may not readily prioritize. It is also plausible that farmers who have tried the technology and have reaped the benefits from trying will always be inclined to seek more information on the technologies, ultimately making them confident to report higher levels of knowledge on soil conservation technologies. Exactly which one comes first in this observation; knowledge in SCTs or high income, appears to require a future investigation in this community. It is possible that some farmers sought best practices including soil conservation knowledge to raise their incomes and continue to do so; in which case knowledge-seeking on SCTs may have come first and higher incomes followed. Secondly, it is also possible that better endowed farmers were able to invest in seeking knowledge in SCTs, in which case higher incomes comes first. The current study design, however, cannot discern between these two possible reasons for the association between income levels and knowledge levels in SCTs.
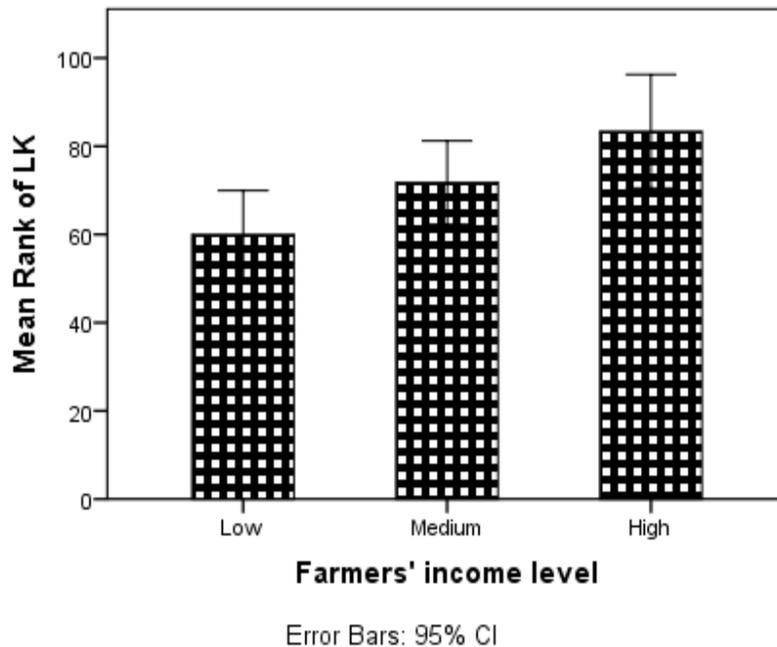

Fig. 4. Mean rank of level of knowledge in soil conservation by income level

Table 2. Gamma and D coefficients between farm/farmers' attributes and level of knowledge on soil conservation

Farm/Farmer Attribute	Gamma (*P* value)	Somers' *D* (*P* value)
Age	-0.098	-0.063
Formal Education	0.300* (0.048)	0.200* (0.048)
Household Size	-0.144	-0.090
Gender	0.416* (0.032)	0.248* (0.032)
Duration as Resident	-0.427* (0.023)	-0.282* (0.023)
Farm slope	-0.190	-0.120
Farm size	0.019	0.012
Farmers income	0.352* (0.003)	0.224* (0.003)

Table 3. Mean rank differences on levels of awareness between groups based on Bonferroni post hoc test

		Under 35	36-45	46- 55	Over 55	
Age	Under 35	X	17.8 (.544)	31.3* (.012)	15.5 (.721)	
	36-45	X	X	13.5 (.625)	-2.2 (1.00)	
	46- 55	X	X	X	-15.8 (.233)	
	Over 55	X	X	X	X	
`Education		Non/Primary	Secondary	Tertiary		
	Non/Primary	X	-1.7 (1.00)	-31.8* (.006)		
	Secondary	X	X	-30.1* (.035)		
	Tertiary	X	X	X		
Number of years in current farm		5 and below	Over 5-10	Over 10		
	5 and Below	X	14.2 (1.00)	24.8* (.048)		
	Over 5-10	X	X	-21.28(1.00)		
	Over 10	X	X	X		
Familiar Technology		Terraces	Stone/thrash	Bio strips	Agroforestry	Rotation
	Terraces	X	19.67* (.035)	-4.9 (.887)	-25.3 (.297)	-64.9(.084)
	Stone /thrash	X	X	-24.6 (.074)	-45* (.002)	-84* (.007)
	Bio strips	X	X	X	-20.4 (1.00)	-60 (.179)
	Agro forestry	X	X	X	X	-39 (1.00)
	Rotation	X	X	X	X	X
Farmers' Income		Low	Medium	High		
	Low	X	-11.7 (.279)	-23.3*(.010)		
	Medium	X	X	-11.6 (.467)		
	High	X	X	X		

In brackets ( ) are P values
*Significant at 5% significance level

4. CONCLUSION

The findings of the study showed that 31.8% of the farmers rated their knowledge on soil conservation as either low or very low. This is of major concern in an environment where nearly all the cultivated lands were on steep slopes and hilly terrains. Information literacy on soil conservation technologies was associated with farmers' level of formal education, gender, duration of residence and farm income levels. These findings have implications for research, policy and for Agricultural extension service providers. Further in-depth research on the underlying causes for this association is recommended. Deliberate investments in soil conservation measures are recommended; particularly to raise the levels of knowledge on soil conservation technologies among the small-scale low-income farmers. Deliberate targeting based on literacy levels, gender and income levels is recommended.

CONSENT

Individual consent was sought from the respondents before data collection.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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