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Gender Differentiated Adoption of Soil and Water Conservation Practices by Farmers in Kenyan Agricultural Highland Catchments

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Soil and water conservation practices or measures are critical in sustaining land productivity for food production while maintaining the integrity of the land. Cardinal measures in this context are broadly categorised as structural, agronomic, and vegetative. Their ultimate goal is to prevent soil erosion, keep the soil fertile, and conserve soil moisture for guaranteed land productivity. This study assessed the relationship between soil biophysical characteristics and farmer socio-ecocomic characteristics on the one hand, and adoption of soil and water conservation practices that have been promoted in the highland catchments of Kinale-Kikuyu, Cherangani, and Wundanyi. A total of 253 households from Kinale-Kikuyu, 96 from Cherangani, and 40 from Wundanyi catchments were selected to form the survey sample. Our results show that among male farmers, the most preferred practices were structural (35.9%), while vegetative practices (29%) were most popular among female land users. At P = 0.3141, our findings indicate that there is no significant relationship between gender and method of soil and water conservation adopted. In Kinale-Kikuyu 31.3% of the farmers adopted vegetative methods, 42.7% of Cherangani farmers used structural methods, and 60.1% of Wundanyi farmers preferred structural methods. These results demonstrated a significant relationship between the catchment location and the method adopted (P = 0.0002). This study

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confirms the successes and benefits of soil and water conservation practices in all three catchments. Significant differences among catchments in the soil and water conservation practices suggest a stronger correlation between adoption and location compared to adoption and gender.

Keywords: Water; catchment; gender; soil; conservation.

1. INTRODUCTION

Soil and water conservation is a component of a sustainable land management framework for using, caring, and improving land. This ensures generation of provisional ecosystem services necessary for improved livelihoods [1]. Prevention and control of land degradation, maintenance of soil fertility, and conservation of soil moisture in the interest of crop water requirements are conventional practices of sustainable land management [2]. Specific measures practiced by farmers depend on various elements such as topography, soil depth, cost implications, and the general ecological zone of the area. The World Overview of soil and water conservation approaches and Technologies [3] describes several measures or technologies of soil and water conservation that are commonly used by farmers, which are broadly categorized as structural/ physical/ mechanical, agronomic/cultural and vegetative/biological. Structural measures entail terrain configuration to intercept and control runoff, increase infiltration, and or safely drain off excess water. Agronomic measures are cultural and are usually associated with crop husbandry practices within cropping seasons and cycles. They are normally independent of slope and do not lead to changes in slope profile but may affect soil organic matter and nutrient content [4]. Finally, vegetative measures include planting selected perennial tree crops and pastures that often result in improved vegetative cover, which is very useful in protecting the soil from direct impact of erosion agents (raindrops and wind). All these measures are not implemented in isolation. They may be combined at the farm or catchment level in cases of trans-boundary catchments. The decision on what to combine to some extent depends on whether such combinations meet the needs of the farmer. According to Sinore et al., [5], farmers in Southern Ethiopia do have significantly different perceptions concerning the effectiveness of physical practices like terraces and soil bunds and biological practices like planting grass. Here, most farmers prefer biological methods (47.86%) followed by combined biological and physical (39.31%) and finally physical methods alone (35.04%). Biological methods were preferred when the intensity of soil erosion was minor, while in case of intense erosion, physical structures were integrated to bolster the survival of vegetation. The integration of methods is associated with multiple benefits like enhanced soil erosion control and reduced costs in the long run.

Soil and water conservation can impart both short and long-term benefits both to upstream and downstream communities [6], especially in highland catchments. For example, a model incorporating proposed conservation practices suggests a projected soil loss reduction by 61% in agricultural lands, 40% in pastoral lands, and 34% in areas of very severe erosion risk [7]. Appropriate use and conservation of highlands resulting in less siltation and cleaner water on the lowlands are now recognized by some emerging economies as important reward policies [8,9]. On the other hand, some economies are yet to mainstream such reward policies [10]. Nonetheless, the ultimate goal of soil and water conservation practices among farmers, then, is the use, care, and improvement of land within supporting policy, legal, social and cultural frameworks [11]. Consequently, it is important for researchers to constantly engage the farming communities to determine the level and diversity of soil and water conservation practices adopted. Such determinations could inform government policies and strategies on what practices have been successful and their level of success in a given agro-ecosystem.

Some of the major challenges that highland catchment communities experience and which still require pro-active soil and water conservation interventions are soil erosion, poor drainage, and declining soil fertility on their farms. This study has selected three of these highlands, namely Kinale-Kikuyu in the central highlands, Cherangani hills in the Rift Valley, and Wundanyi on the Eastern Arc mountain range for assessment. They represent agricultural highland ecosystems that have high crop production potential but are also densely populated thus placing degradation pressure on the environment. Deforestation, encroachment on wetlands, and farming on sleep land have contributed to land degradation in these catchments. The negative impacts of land degradation following extreme rainfall events have included massive landslides in the highlands and siltation in lowland water bodies. The objective of this study, then, was to assess the relationsionship between soil biophysical and farmer socio-economic characteristics on the one hand and adoption of various soil and water conservation practices that have been promoted in these three highland catchments, in order to keep learning and adjusting conservation policies as the need may be.

2. MATERIALS AND METHODS

2.1 Study Area Characteristics

The three study sites of Kinale-Kikuyu, Cherangani and Wundanyi represent agricultural mountain ecosystems where previous interventions involving promotion of soil and water conservation practices were undertaken. Gitau (Unpublished results) has described the profiles of the study areas. The Kinale-Kikuyu catchment lies mainly in the Upper Highland agro-ecological zone, with some of the areas being located in the Lower Highlands agro-ecological zones with rainfall of up to 2,000 mm per annum [12]. Geographically it lies between $0^{o}50^{'}0^{''}$S, $1^{o}00^{'}0^{''}$S and $36^{o}30^{'}0^{''}$E, $36^{o}70^{'}0^{''}$E. The Cherangani catchment is located along the central part of Rift Valley. This catchment receives a mean annual rainfall of about 800 mm to 1,200 mm. The catchment traverses the Upper Highland, Lower Highlands, Lower Midlands, and Tropical Alpine agro-ecological zones and is found between $0^{o}50^{'}0^{''}$N, $1^{o}40^{'}0^{''}$N and $35^{o}00^{'}0^{''}$E, $36^{o}00^{'}0^{''}$E. Kinale-Kikuyu and Cherangani catchments are gentle to moderately sloping landscapes [13]. The Wundanyi catchment lies between $3^{o}20^{'}0^{''}$S, $3^{o}30^{'}0^{''}$S and $38^{o}15^{'}0^{''}$E, $38^{o}40^{'}0^{''}$E. It is located at an altitude of about 1,600m on Taita hills and receives up to 1,250 mm of rainfall per annum. The Wundanyi catchment lies in Lower Midland agro-ecological zones [14]. Wundanyi has further experienced environmental degradation as the farming community expands its farms into forests and previously unfarmed steep slopes

2.2 Sample Size and Sampling Procedure for Household Surveys

A cross-sectional survey was conducted in the three water catchments. A total of 253 households from Kinale-Kikuyu, 96 households from Cherangani, and 40 households from Wundanyi catchments were interviewed to make a total sample size of 389 households. In each of the catchments, three administrative sub-locations were selected based on the agro-ecological zones and slope gradient. Within the sub-locations, a stratified random sampling technique [15] was used to allocate to each village the number of households to be interviewed. Finally, households cutting across gender and wealth were randomly selected in each village from the list of residents maintained by the sub-location administrator. Non-farming households were, however, excluded from the survey.

2.3 Data Collection and Analysis Methods

Data was collected using a questionnaire, developed in a consultative and participatory manner, that contained both structured and unstructured questions. The questionnaire was pre-tested for clarity and necessary adjustments made to enhance its usefulness. Data were collected between August and November 2015 in all three catchments. The results of the study were further evaluated by the Ministry of Agriculture policymakers in a workshop held in January 2016. While some changes on adoption of soil and water conservation practices on the ground may have occurred since the study, they are not considered significant because of the slow nature of technology adoption in rural agriculture, as discussed by Aboh [16].

Data collation, storage, and statistical analysis were done using Microsoft Excel, version 2007. Descriptive and inferential statistics were conducted to reveal patterns and relationships among the variables. Quantitative data were used to determine means and standard deviations. Categorical data were summarized into frequencies. Further analysis of these data involved the determination of associations among data categories using the Chi-square statistic (χ^2) as described by Rana and Singhal [17]. The research question that guided this study sought to describe adoption practices in the various catchments but did not attempt to model any input-output relationships. Inferential data analysis was therefore limited to Chi-square statistics.

3. RESULTS AND DISCUSSIONS

3.1 Socio-economic Profiles of the Catchment Communities

About 90% of the respondents in each site indicated being primarily farmers. As such, they interacted with their farms daily in pursuit of livelihood necessities. The study also reports the effect of gender on adoption of soil and water conservation practices because it is critical in informing future policies and planning. In all the three catchments, more male than female farmers were sampled thus: 66% male and 34% female in Kinale-Kikuyu, 68% male and 32% female in Cherangani, and finally 73% male and 28% female in Wundanyi. Our results show that over 80% of the farmers had at least a primary level of education, while less than 10% indicated having obtained a college education. Education is important for being aware of current and emerging technologies. Mekuriaw et al. [18] also suggest that adoption of conservation practices largely depends on awareness of the existence and benefits of such practices as created by extension services. Similar to our results, Kirui and Mirzabaev [19] also reported that having some level of education enables farmers to appreciate the importance of soil and water conservation practices. Mango et al. [20] bolster this view when the observed that targeting well-educated farmers in future sustainable soil and water conservation initiatives will likely accelerate early adoption and ultimately greater acceptance and adoption by the rest of the farmers, as they appreciate demonstrable benefits. About 3% of the respondents indicated that their main occupation is teaching but are engaged in farming to generate additional income. Although few, these teachers who double up as farmers are drivers of change that could enhance the promotion of soil and water conservation practices because of the venerable position they occupy in rural societies. Therefore, soil and water conservation extension activities also also observed by Darkwah et al. [21] should not only target farmers *per se* but also opinion leaders in order to maximise on the adoption multiplier effect.

Statistics for land ownership, segregated by gender, vary from site to site as presented in Table 1. Cherangani respondents, on average, own the largest pieces of land, followed by Kinale-Kikuyu and finally Wundanyi. These results also show that female farmers in Kinale-Kikuyu own larger sizes of land than male farmers. This is a counterintuitive result whose reasons are worthy of further research. The scenario is different in Cherangani and Wundanyi because male farmers own larger sizes of land than their female counterparts. Both Kinale-Kikuyu and Cherangani show wide ranges in land size owned compared to the land owned by Wundanyi farmers as shown by the standard deviations. The minimum farm size owned in Kinale-Kikuyu was 0.1 acres while the maximum was 100 acres. In Cherangani, the minimum was 0.3 acres and the maximum was 70 acres while Wundanyi farmers reported a minimum of 0.3 acres and a maximum of 8 acres. Ruzzante and Bilton [22], Mudassir et al. [23] and Darkwah et al. [21] observed that farmers with larger farms were more likely to adopt conservation practices. However, our results further suggest that, depending on the farm size, farmers preferred different types of conservation practices, as discussed later.

The terrain in Kinale-Kikuyu is relatively flat, and the population density lower compared to Cherangani and Wundanyi. Conversely, Cherangani is characterized by government planned settlement schemes where land sizes were generally limited to a maximum of about 10 acres at scheme inception. Wundanyi is hilly and the population density is highest among the three catchments thus reducing the amount of land owned per capita. Population density is a critical variable in a successful soil and water conservation program because high densities beyond 600 persons per km^2 are positively correlated with reduced soil fertility [24]. In contrast, Tiffen et al. [25] observed that more people do not necessarily cause more erosion. These catchments are predominantly rural, and the main economic activity is agriculture. This scenario increases the probability of successfully transferring soil and water conservation technologies because the recipient farmers are likely to embrace such technologies with undivided attention, so as to enhance their major source of livelihood. Many farmers in Kinale-Kikuyu engage in commercial horticulture compared to those in Cherangani who focus on comparatively lower value food crops such as cereals (Mcharo and Maghenda, 2021). This is partially because Kinale-Kikuyu is close to large fresh produce markets in Nairobi and Naivasha. On the other hand, farmers in Wundanyi are generally at the subsistence level and few are motivated to commercially produce.

3.2 Adoption of Categories of Soil and Water Conservation Practices

We considered that a practice was adopted by the respondent if it was being used on the farm. Our investigation found that the majority of the farmers in the study catchments (62.9% in Kinale-Kikuyu; 74.4% of Cherangani and 90% in

Wundanyi) have adopted at least one soil and water conservation practices and even multiple integrated practices, as also reported by Kirui and Mirzabev [19]. The oldest soil and water conservation method in use recorded was terracing at 26 years in Wundanyi. Level or infiltration ditches in Cherangani followed with 25 years. In Kinale-Kikuyu terraces and level ditches were also relatively old at 22 and 21 years respectively. Further, in Kinale-Kikuyu grassed waterways were 19 years old. Generally, there were more diverse, older, and greater numbers of soil and water conservation structures in Kinale-Kikuyu compared to Cherangani or Wundanyi. Among the male farmers, 35.9% used structural soil and water conservation practices, 29.6% used vegetative practices while another 5.5% reported using agronomic practices. Female farmers favoured vegetative methods (29%) followed by structural methods (27.4%) and finally agronomic practices (8%). This study found that 28.8% of the males and 35.6% of the females did not use any soil and water conservation practices. When the results were differentiated by catchment, 31.3% of Kinale-Kikuyu farmers adopted vegetative methods, 24.5% structural methods, and 7.2% agronomic methods. Among farmers from Cherangani, 42.7% used structural methods, 26.8% vegetative methods, and 4.9% agronomic methods. Wundanyi farmers preferred structural methods (60.1%) followed by vegetative methods (24.9%) and lastly agronomic methods (5%). The most preferred conservation practice by the males in Wundanyi was either Fanya Juu terraces solely (31%), which have been promoted in the past [26] or a combination of terraces and Napier grass (27.6%). Napier grass is the most affordable source of fodder for dairy farmers in Wundanyi. Adoption of certaine types of soil and water conservation practices in these catchments was motivated by the challenges of soil erosion and declining soil fertility experienced on the farms. The specific practices adopted by each farmer were not investigated due to resource constraints. The proceeding section reports and discusses adopted soil and water conservation practices with respect to these challenges.

3.3 Soil Erosion

Our study shows varied perceptions of the intensity of soil erosion on farms (Fig. 1). Most of the Kinale-Kikuyu farmers reported minimal soil erosion followed by Cherangani and finally by Wundanyi farmers. On the other hand, 55% of the Wundanyi farmers felt that soil erosion was either mild or severe followed by Cherangani with 54.17%. This could be attributed to the fact that the steepest slopes were observed in the Wundanyi catchment followed by Cherangani while Kinale-Kikuyu is either flat or gently sloping. In addition, the occurrence of soil erosion could be due to several dynamics including appropriateness of soil and water conservation practices in place, rainfall intensity and amounts, and soil types. Labrière et al. [27] suggest that any activity making soil bare, which includes cultivating steep slopes in Wundanyi, would promote erosion while appropriate soil and vegetation management may reduce soil erosion by up to 99%.

In our study catchments, farmers mitigated the effects of erosion in several ways. Among the agronomic practices used were contour farming and cover crops. The structural practices adopted were cut-off drains, *Fanya Juu* terraces, terraces combined with Napier grass, bench terraces combined with trees, and bench terraces combined with contour planting. Finally, vegetative practices adopted included planting Napier grass, planting selected trees, and grass stripes. Obinna [28] reported that trees and bunds were particularly popular among rice farmers. Results from all the three catchments suggest that there was a predominance of terrace use as a soil and water conservation approach. At least 50% of the respondents in all sites had built terraces, which is indicative of the risk of erosion imposed by a slope. Fanya Juu terraces are popular on steep land as also observed in the Minchet catchment of northern Ethiopian Highlands by Subhatu et al. [29]. Kinale-Kikuyu respondents reported that the major interventions they used to deal with soil erosion were Fanya Juu terraces followed by Napier grass (Table 2). In Cherangani, farmers constructed Fanya Juu terraces and also planted trees. More females than males opted to plant trees possibly because females, who generally do the cooking, planned on using the trees as a source of fuel in the future. Other popular soil erosion control practices were planting Napier grass and a combination of bench terraces and trees or bench terraces and contour cultivation. In contrast, popular soil erosion control methods in North-west Ethiopian highlands are soil bunds, stone bunds, and strip cropping [30].

Table 1. Land Ownership by Gender

Water Catchment	Gender	N	Total area of land owned (acres)	
			Mean	Std. Deviation
Kinale-Kikuyu	Male	161	4.53	7.77
	Female	82	5.00	12.62
Cherangani	Male	65	6.83	9.75
	Female	31	4.56	5.59
Wundanyi	Male	29	2.49	1.71
	Female	11	1.11	0.82

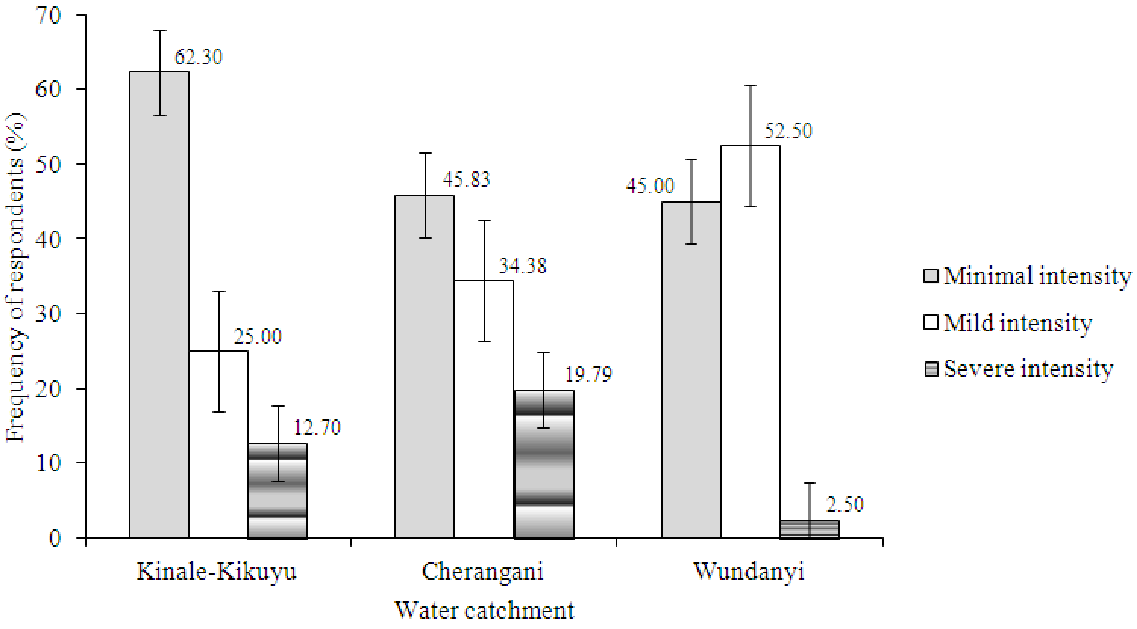

Fig 1. Perception of the effect of soil erosion

Table 2. Most common methods of soil erosion control differentiated by gender in each catchment

Catchment	Method of controlling soil erosion	Respondents by gender (%)[1]	
		Male	Female
Kinale-Kikuyu	Fanya Juu terraces	19.30	19.50
	Planting Napier grass	12.00	13.80
	Planting trees	12.00	5.70
Cherangani	Fanya Juu terraces	21.50	6.50
	Planting trees	10.80	19.40
	Planting Napier grass	9.20	9.70
Wundanyi	Fanya Juu terraces	31.00	9.10
	Fanya Juu terraces combined with Napier grass	27.60	27.30
	Planting Napier grass	10.30	27.30

[1]*Respondents often adopted multiple methods of controlling soil erosion*

Table 3. Regional and gender variation in the adoption of soil fertility enhancing practices

Soil fertility measure adopted	Inorganic fertilizer used or not	Level of adoption (%)					
		Kinale-Kikuyu		Cherangani		Wundanyi	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**
Farm Manure and Inorganic Fertilizer	Yes	76.40	78.05	48.08	72.41	52.17	77.78
Inorganic fertilizer	Yes	7.45	4.88	9.62	6.90	-	-
Compost manure and inorganic fertilizer	Yes	1.86	4.88	-	-	-	-
Crop rotation and inorganic fertilizer	Yes	-	-	1.92	-	-	-
Farm manure	No	11.80	10.98	13.46	13.79	47.83	22.22
Compost manure	No	1.24	1.22	11.54	6.90	-	-
Crop rotation	No	-	-	5.77	-	-	-
Crop rotation and farm manure	No	1.24	-	5.77	-	-	-
Terracing and crop rotation	No	-	-	3.85	-	-	-
Total		100	100	100	100	100	100

The other approaches that were common in all catchments, although less used, were infiltration ditches, ponds, trash lines, and contour bunds. Infiltration ditches were more common in Kinale-Kikuyu to facilitate percolation of the high rainfall into deeper soil levels. On the other hand, contour bunds were more common in Wundanyi probably because of the benefits of contour farming on steep slopes. Contour bunds are also common in the Chinyanja Triangle of Southern Africa, although the region has more gentle slopes [20]. Conversely, in select European countries, contour farming is used less to control soil erosion because of its temporary nature, and limited application, compared to the more effective and long term grass margins and stone walls [31]. Results from our study suggest that the most common vegetative practices for soil and water conservation in all study sites were planting of trees based on tacit knowledge of agroforestry. For instance, boundary trees generally do take up very little production land. In addition, once mature, they are sold for additional income. Other tree species provide farmers with additional animal feed and, in some cases, firewood. Only respondents from Kinale-Kikuyu and Cherangani planted woodlots, possibly because of their larger farm sizes compared to Wundanyi. Contour hedges were found only in Wundanyi, possibly because of the steep terrain. The integration of structural, agronomic, and vegetative practices is a best practice because it is associated with multiple benefits. In this regard, 20% of the respondents in both Cherangani and Wundanyi and 2% in Kinale-Kikuyu had trees on terraces. This combination of soil and water conservation practices provides an opportunity for improving the effectiveness of the terraces, reducing the effect of run-off, and also providing firewood from pruned branches. In later years, mature trees may provide timber for the owner, depending on the species of trees planted. Where soil and water management practices are inadequate or absent, negative effects have been reported. To elucidate this point, a study on the River Njoro watershed in Kenya by Mainuri and Owino [32] suggests that soil aggregate stability, the ability of soil to resist degradation when exposed to forces of erosion as measured by the soil's mean weight diameter, is highest in forest land (0.68), followed by grassland (0.64), agricultural land (0.58) and finally wetlands (0.41). A related study by Merten and Minella [33] presents various scenarios on the effect of different agricultural practices on soil erosion in Brazil. They suggest that expansion of agriculture into native vegetation without the adoption of conservation practices could increase total erosion in Brazil by 20%, while expansion with conservation practices could decrease erosion by 20%. In another study, Willy et al. [24] suggest that agricultural intensification results in deteriorating soil quality as population density increases. These results suggest that many opportunities are available to initiate and promote soil and water conservation projects and programs in the catchments that we studied and in areas with related terrain profiles. The fact that the respondents in our study perceive erosion to be an issue of concern on their farms suggests that they could be open to trying out new practices that would reduce the degeneration of their land assets. We suggest easy to implement educational programs that highlight the benefits of soil and water conservation practices as the first initiative in order to prepare the communities for more intensive on-farm interventions.

3.4 Declining Soil Fertility

Apart from soil moisture content, soil fertility is the other major determinant of land productivity and is managed using various options including combinations of biological and inorganic fertilizers [34] as also discussed further in our results. In our study, the majority (89.8%) of those interviewed reported a negligible to moderate decline in soil fertility on a scale of negligible-moderate-severe. Among the farmers in Wundanyi, 82.1% said that soil fertility had declined moderately to severely. This was attributed to farmers having small farm sizes, ranging from a mean of 1.11 acres for females to 2.49 acres for males, thus contributing to intensive use, over-cultivation, lack of crop rotations, and hence soil mining. Rice farmers in Nigeria used compost manuare and crop rotation to maintain fertility [28]. Other farmers in Wundanyi used soil degrading inorganic fertilizers, like phosphorus-based fertilizers that have a long residue effect, for a prolonged period in the past. Some farmers in Kenya have therefore responded to this by encroaching onto adjacent steep and forested land, further accelerating loss of soil erosion and fertility decline [35]. The scenario in Kinale-Kikuyu and Cherangani is more encouraging. Land sizes in these two catchments are larger and consequently the farmers relatively better off financially to afford soil amendment interventions. Consequently, the use of manure and other soil fertility enhancing practices by farmers in these catchments has likely maintained the soil fertility status as has been demonstrated in other parts of Kenya [36] and Ethiopia [37]. Where farmers experienced severe soil fertility decline in Kinale-Kikuyu and Cherangani, one of the possible causes included leaching due to high rainfall. The practices used by most farmers to reverse declining soil fertility were the use of a combination of farm manure and inorganic fertilizer or farm manure alone (Table 3).

In Kinale-Kikuyu, over three-quarters of both male and female farmers used a combination of farm manure and inorganic fertilizer. On the other hand, Cherangani had a slightly lower proportion of farmers using this combination (72.41% female and 48.04% male farmers). Male farmers in Cherangani were more diverse in the soil fertility management options that they used as presented in Table 3. In Wundanyi farmers limited themselves to either a combination of manure and inorganic fertilizer or manure alone (Table 3). Manure helps in improving soil structure, especially soil porosity, which promotes root development and water infiltration [38]. Other studies show that farmers use integrated soil fertility management strategies like organic manure and intercropping to mitigate declining soil fertility and related issues [39]. The use of farm manure may have been extensive because of its availability on-farm and its affordability. Those who use farm manure alone in Kenya frequently do so because they cannot afford inorganic fertilizers and also because manure has discernible long-term effects. Hoover et al. [40] found that continuous application of poultry manure over 20 years resulted in soils that could hold more water and that had higher infiltration compared to soils treated with Urea-ammonium nitrate. Inorganic fertilizers alone were hardly used. Inorganic fertilizers were used by farmers producing high-value crops, which was mostly in Kinale-Kikuyu. However, the addition of inorganic fertilizer by itself may not improve crop yield, especially in high altitude catchments, if the risk of leaching is not well managed [41]. This scenario underscores the importance of integrated soil fertility management interventions. Compost manure was rarely used perhaps because it is a tedious process requiring large quantities of organic resources and knowledge in preparing compost. Further, crop rotation was rarely practiced. This reluctance is associated with the farm sizes which were too small to practice rotation of the main crop, mostly vegetables, cereals, legumes, and potatoes, economically. Within each catchment, these crops were seasonally grown depending on their suitability and performance under the prevailing weather.

3.5 Associations among Farmer Characteristics

The results were differentiated by gender and catchment, as suggested by Cruz-Garcia et al. [42], to elucidate any significant differences in perceptions on ecosystem management. There are gender differences in what the farmers perceived as the real soil and water challenges on their farms and also in the level of adoption of some of the soil and water conservation practices. Villamor et al. [43] also found similar gender variations. Such differences may be due to unequal appetite for risk and unequal access to resources between males and females. There was no significant relationship between gender and the soil and water conservation method adopted (χ^2 = 3.5518, P = 0.314) as presented in Table 4.

Further analysis showed that there was a significant relationship (χ^2 = 25.8806, P = 0.0002) between the catchment and the soil and water conservation method adopted with many of Kinale-Kikuyu farmers (37.2%) adopting no method followed by 31.2% who preferred vegetative methods. On the other hand, structural methods were the most preferred in Cherangani, by 42.7% of its farmers, and also in Wundanyi by 60% of its farmers. This study shows that there is no significant relationship between gender and the perception of soil erosion (χ^2 = 0.6669, P = 0.7164). As such both female and male farmers can be involved in extension activities to monitor erosion risks and take requisite prevention and control measures. Also, we found no significant association between gender and type of soil and water conservation intervention adopted (χ^2 = 3.5518, P = 0.3141). On the other hand, Ngigi et al. [44] noted that significantly more female farmers adopted soil management strategies like using cover crops and crop rotations compared to male farmers who focused more on agroforestry to manage their farms. Preferred tree species for agroforestry were *Cedrus deodara* and *Grevillea robusta*. Iyilade et al. [45] found that gender was also associated with adoption of conservation practices in Nigeria. Belachew et al. [30] found that female household heads were more likely to adopt strip cropping and older household heads were less likely to adopt soil bunds in Ethiopia. There was no significant relationship between

. **Table 4. Association between farmer profile and farmer responses**

Independent variable	Response variable	df	Chi-square	P value
Location of farmer[1]	Farmer perception of soil erosion intensity on-farm (minimal, mild, severe)	4	19.9592	0.0005
Gender of farmer[2]	Farmer perception of soil erosion intensity on-farm (minimal, mild, severe)	2	0.6669	0.7164
Location of farmer	Category of soil and water conservation practice adopted (none, agronomic, structural, vegetative)	6	25.8806	0.0002
Gender of farmer	Category of soil and water conservation practice adopted (none, agronomic, structural, vegetative)	3	3.5518	0.3141
Location of farmer	Farmer perception of level of soil fertility decline on-farm (negligible, moderate, severe)	4	6.4518	0.1678
Location of farmer	Use of inorganic fertilizer (used fertilizer, did not use fertilizer)	2	23.2726	0.0000
Gender of farmer	Use of inorganic fertilizer (used fertilizer, did not use fertilizer)	1	3.3661	0.0666
Location of farmer	Farmer perception of soil waterlogging on-farm (negligible, moderate, severe)	4	13.1439	0.0106
Gender of farmer	Farmer perception of soil water logging on-farm (negligible, moderate, severe)	2	33.7097	0.0000

[1]Catchment of a farmer is Kinale-Kikuyu, Cherangani, or Wundanyi
[2]Gender of a farmer is either male or female

catchment and perceived level of the decline of soil fertility suggesting that soil fertility challenges are fairly similar on the selected highland catchments. Additional analysis showed that there was no significant association between gender and use or no use of inorganic fertilizer as a means of improving soil fertility. On the other hand, there was a significant relationship between catchment and the use of inorganic fertilizer, with the majority of the farmers opting to use inorganic fertilizer in all the catchments. The farmers did not report a severe problem with waterlogging, which in turn could affect soil fertility. Fifty-eight percent of the farmers either did not report drainage problems on their farms or felt that drainage challenges were negligible or insignificant on a scale of negligible-moderate-severe. However, there was a significant relationship (χ^2 = 13.1439, P = 0.0106) between perception concerning water logging experienced on-farm and the location of the catchment and also between waterlogging and gender (χ^2 = 33.7097, P = 0.0000). Waterlogging is usually a result of soil type, slope and shape of the land, irrigation system and even level of aridity of the landscape [46,47].

4. CONCLUSION

This study confirms the successes and benefits of soil and water conservation practices in all three catchments. Significant differences among catchments in the soil and water conservation practices adopted point to a greater association of practices adopted with the location of the catchment compared to the association of practices adopted with gender. This study, then, reinforces the importance of locality-specific integrated strategies in soil and water conservation. For increased adoption of conservation practices, extension services should, therefore, focus on location and farmer objectives. Gender differentiation of the results shows that female farmers favoured soil and water conservation practices that would enhance their access to resources like water and fuel (charcoal and firewood). Male farmers, on the other hand, chose minimum-maintenance conservation practices like terraces and cut-off drains. These practices allow the men to engage in other activities and also minimize the cost of maintaining soil and water ecosystems on the farm. However, there is an opportunity for more research on the role of gender and also the reasons for using particular soil fertility management practices, having not been investigated in this study.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

The authors declare that they have no known competing interests, financial or otherwise, or personal relationships that could have appeared to influence the work reported in this paper

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