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Farmers' Level of Knowledge on Different Watershed Management Technologies Promoted In the Catchments: A Case of Tende and Kibuon Catchments in South West, Kenya

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Abstract
Background: *Water and soil are important natural resources for agricultural production which play a major role in economic growth World-wide (Heiner, Shames & Spiegel, 2016). Through social and economic activities by man, half of the Earth's land surface has been transformed making it susceptible to degradation. Watershed management technologies have been piloted in many countries in the World as best solutions to alleviate degradation. However, their implementation has been hampered by various constraints (Wamalwa, 2009). Kibuon and Tende catchments are located on Eastern side of Lake Victoria in South West Kenya. The catchments were characterized by soil and water degradation with reduced water base flow and increased poverty.*
Materials and Methods: *Through Integrated Project Extension Approach,an Integrated Land and Watershed Management Project (ILWMKTP) used watershed management technologies to control degradation. The survey was conducted in the catchments which cover Homa Bay, Kisii and Nyamira Counties. Target population was 9,475 farmers while accessible population was 370 respondents. Kibuon catchment was divided in 3 sub catchments; Kibuon (K1), Kabondo (K2) and Kasipul (K3) sub catchments. Kasipul (K3) sub catchment had more knowledge on watershed management technologies controlling watershed degradation while few respondents from Mogusii T3 had the knowledge.*
Result: *Kibuon K2 had the highest level of knowledge on soil and water conservation technologies by ranking first in 5 technologies in column 1; Kasipul K3 ranked first in 3 technologies in column 2; Isanta T2 was ranked first in 3 technologies in column 3; Kibuon K1 and Mogusii T3 were each ranked 1 in two technologies each in column 4. In column 5 Kibuon K1 and Mogusii T3 were ranked first in two technologies each. Tende T1 was ranked first in 3 technologies in column 6. Frequency table showing those who agreed to positive statements on watershed management technologies showed that above 50 percent of respondents agreed on all the technologies; terracing, contour ploughing, check dams, grass strips and retention ditches controlling watershed degradation except cover cropping which had 39.2 percent*
Conclusion: *Respondents attained different levels of knowledge, on watershed management technologies promoted in the catchments and there were different levels of technology uptake in each sub catchment.*
Keywords*: Watershed management technologies, catchments and land degradation*

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I. Introduction

Across the World water and soil are important natural resources for agricultural production which play a major role in economic growth of any country (Heiner, Shames & Spiegel, 2016). Social and economic activities by man have transformed half of the Earth's land surface making it susceptible to degradation and watershed degradation. Watershed management technologies have been piloted in many countries in the World as best solutions to alleviate water resource challenges. However, their implementation has not been successful due to various constraints (Wamalwa, 2009). Kibuon and Tende rivers catchments are located on Eastern side of Lake Victoria in South West Kenya. The catchments were characterized by soil and water degradation which resulted in reduced water base flow and increased poverty. Benefits of watershed management in any part of the world cannot be overstated, for that reason, an Integrated Land and Watershed Management Project in Tende and Kibuon catchments was initiated to increase land productivity and improving water quality and quantity in the watersheds. Through African Water Facility the agricultural extension programme planning and implementation interventions used an Integrated Project Extension Approach in Kibuon and Tende Integrated Land and Watershed Management Project (ILWMKTP) to control degradation.

II. Material and Methods

The survey was conducted in rivers Kibuon and Tende catchments which cover Homa Bay, Kisii and Nyamira Counties in South West Kenya. According to the census for 1999 in African Water Facility, (2008) total beneficiaries were 1,884,000 farmers but the Integrated Land and Watershed Management Project in the catchments covered 9,475 farmers. Accessible population was 370 respondents and 9 key informants who participated in implementation of the project. Kibuon catchment was divided in 3 sub catchments; Kibuon (K1), Kabondo (K2) and Kasipul (K3) sub catchments. Tende (T1), Isanta (T2) and Mogusii (T3) sub catchments are in Tende catchment. Each catchment had three sub catchments hence the numbers 1-3 in each catchment.

Study Design: The design was an ex post facto research design with cross sectional survey approach combining qualitative and quantitative data collection and used primary and secondary data.

Study location: The study was carried out in Tende and Kibuon rivers catchment which drains through Homa Bay, Nyamira and Kisii Counties in Kenya.

Study duration: The study ran from late October 2018 to early January 2019

Sample Size: Sample size was 370 farmers who implemented Integrated Land and Watershed Management Project in Tende and Kibuon

Samplesize calculation: A sample size table by Krejcie and Morgan (1970) in a research paper by Hashim, (2010) recommends a sample size of 370 respondents from a population of 10,000 people. The study covered 370 respondents who were distributed to each sub catchment proportionately and the confidence level was set at 95%.

Subject &selection method

The study area was selected purposively for having implemented a watershed management project. Multiple-stage cluster sampling method was used proportionately. The study area was divided into different blocks representing sub catchments based on the area where the project was implemented and each sub catchment was represented by a number of CBO members. Through proportionate simple random sampling, 50 per cent of the CBOs were selected for the study. Simple random sampling was used to get respondents proportionately in each CBO. From 68 CBOs, 34 CBOs were systematically selected each member was selected through simple random sampling procedures.

Inclusion criteria:

Farmers who participated and implemented Integrated Land and Watershed Project in Kibuon and Tende catchments

The study involved men and women

Those involved were above 18 years

Those who were selected through systematic sampling

Exclusion criteria

Farmers who did not implement the Integrated Watershed Management Project were not included in the survey.

Procedures methodology

A research permit was sought from National Commission of Science, Technology and Innovation (NACOSTI) through Kisii University. Department of agriculture in the study area was informed. Data was collected from respondents through face to face interview. The study utilized primary and secondary data, and literature was collected from books, journals, reports, policy documents and research papers. There was triangulation of data from the farmers and extension staff to inform conclusions that were drawn.

Statistical Analysis

Quantitative data was analyzed using statistical package for social sciences version 25. Qualitative data was dummy coded and analyzed using IBM SPSS. The analysis was done in terms of variables for the objective in the study. Data was analyzed using descriptive and inferential statistics. Descriptive statistics was used to determine means and standard deviations and frequencies among sub catchments in terms of watershed management technologies. For inferential statistics, ANOVA was used to compare means in sub catchments on watershed management technologies. Tukey post hoc determined significant differences on watershed management technologies. The results were rated on a 5 point likert scale where 1 represented strongly disagree, 2 was disagree, 3 was neutral, 4 was agree and 5 represented strongly agree. Level of significance for inferential statistics was set at 0.05%.

III. Results

Gender of the Respondents

The study interviewed 370 respondents who comprised of 63.2 percent men and 36.8 percent women. Majority of project implementers (234) out of 370 were men while 136 were women. Most women participated in biological and alternative economic enterprises that did not require a lot of energy to establish for example poultry, goat production and fish farming in the catchments. Men made decisions on how land should be utilized and provided labour for tedious work in terms of terraces construction. It was expected that men in the project would influence women positively towards watershed management technologies and engage them in some field activities through provision of labour. These findings agreed with a research report by Wagayehu and Lars (2015) in their study on "Adoption of soil and water conservation measures (SWCM) by subsistence farmers in the Eastern" part of Ethiopia which established that although men were heads of households and responsible for decision making on farm activities, women constituted primary labour. Increase in labour requirements in soil and water conservation activities is achieved through involvement of women in farm activities to control soil erosion by implementing decisions made by men. According to Tennyson (2005), in his study on "Review and Assessment of Watershed Management Strategies and Approaches", FAO promoted participation of men and women in activities in their watershed programmes and their direct involvement has been successful through provision of labour and skills in technology establishment in watersheds thereby increasing uptake rate (Table 4).

Age of Respondents

Majority of the respondents (74.3 percent) were above 40 years of age and most of them were between 50-60 years old while 5.7 percent were below 40 years of age. Respondents below 30 years represented the lowest percentage (1.4) of the total sample size. Data analysis indicated that participation in watershed management technologies was influenced by age. Older people valued land more than young people therefore made the decision to participate in soil and water conservation activities to conserve the watersheds which improved soil fertility and translated in increased productivity. This is in line with findings by Bayard, Jolly and Shannon (2006) in their study on " Adoption and Management of Soil Conservation Practices in Haiti: The Case of Rock Walls" which indicated that age influenced participation in soil and water conservation whereby uptake increased with progression in age which was also reported by (Sheikh, Redzuan, Samah, & Ahmad, 2014) in their study on " Factors Influencing Farmers' Participation in Water Management: A Community Development Perspective"

4.2.3. Marital Status

Majority of the respondents interviewed were married (99.5 percent). Married men had more labour for technology implementation provided by wives and children unlike those who were not. The project worked with men, women and youth who were either married or single. Men made decisions on which soil and water conservation technologies to be taken up on their farms while women implemented decisions made by men through provision of family labour. The women participated in watershed management to restore their farms and improve on productivity in maize, milk and forage for improved household income. Rehema (2014) reported similar observations in her study on "Factors Influencing Adoption of Soil Conservation Measures, Sustainability and Socio economic Impacts among Smallholder Farmers in Mbeya rural District in Tanzania" which established that married women participated in soil conservation to increase family income although decisions on technologies were made by men. German, Mansoor, Alemu, Getachew, Mazengia, and Stroud, (2006) confirmed in their study on " Participatory integrated watershed management: Evolution of concepts and methods in an eco-regional program of the Eastern African highlands" that successful watershed management needed to address constraints affecting both women in relation to decision made by men in the catchment for active participation by family members. There is need to consider female domains like reduced areas under agroforestry reflected in less wood fuel and how land use practices affected livelihoods of the people living in catchments.

Farmer's Level of Education

Most of the respondents attained primary level followed by secondary level of education and the least percentage (1.4 percent) of respondents attained tertiary level. This analysis showed that farmers participated and were able to implement soil conservation technologies as long as they were taken through the trainings as long as they had basic education which was similarly reported by Lesch and Wachenheim (2014) in their study on "Factors Influencing Conservation Practice Adoption in Agriculture: A Review of Literature" which established that education was found to be inconsistent in participation of respondents in soil and water conservation technologies. Participation in watershed management technologies increases with proper trainings regardless of academic background which does not agree with findings by Sheikh et al. (2014) in their study on" Factors Influencing Farmers' Participation in Water Management: A Community Development Perspective" who found out that education influenced implementation of soil and water conservation technologies in the catchment.

Size of Family

Respondents had varied family sizes majority had more than 5 family members (70 percent), followed by 5 members (23.8 percent), then the rest had between 2- 4 family members. A high number of households provided labour that was required in participation of watershed management technologies in the catchments which did not agree with a study by Tadesse and Belay (2004) on "Factors Influencing Adoption of Soil Conservation Measures in Southern Ethiopia: The Case of Gununo Area" which established that family size affected participation in watershed management technologies negatively. Big family sizes capitalized on short term benefits and would not consider participating in soil conservation whose benefits are long term. Similar findings were reported by Mutuyimana (2015) in her findings on "Effects of integrated soil and water management on livelihoods of smallholders in Burega sector, Rulindo District, Northern Province, Rwanda" which reported family size being important for active participation by farmers in soil and water conservation.

Size of Land

Land sizes varied widely and ranged from ½ an acre to more than one acre. Half of the respondents (49.7 percent) owned more than one acre, thirty nine point nine percent (39.9 percent) owned one acre and 10.8 percent had less than one acre of land. Most of the respondents who implemented Integrated Land and Watershed Project in Tende and Kibuon had more than 1 acre of land because some of the technologies required more space for their construction while those with smaller pieces of land put one retention ditch on the upper part of their farms and invested in cover crops and agroforestry along the fence. These findings were also reported by Tadesse and Belay (2004) on "Factors Influencing Adoption of Soil Conservation Measures in Southern Ethiopia: The Case of Gununo Area" who reported size of land being positive and significantly influenced uptake of soil conservation technologies. Smaller sizes of land restricted implementation of physical technologies which agreed with findings by Mutuyimana (2015) on "Effects of integrated soil and water management on livelihoods of smallholders in Burega sector, Rulindo District, Northern Province, Rwanda" which established that size of land affected uptake of soil and water conservation technologies.

FARMERS' LEVEL OF KNOWLEDGE ON WATERSHED MANAGEMENT TECHNOLOGIES

Cover Cropping Contributed to Watershed Management

Through descriptive statistics Kibuon K2 had the highest mean of 3.74 with standard deviation of 1.896, Isanta T1 had a mean of 3.49 and standard deviation of 0.748, Kasipul K3 had a mean of 3.41 and a standard deviation of 0.942. Kibuon K1 had a mean of 3.40 and standard deviation of 1.056, Tende T1 had a mean of 3.23 and standard deviation of .757. The mean for Kibuon K2 was the highest which indicated that many farmers in that sub catchment had more knowledge on cover cropping contributing to watershed management compared to Mogusii T3 (Table 120).

Table 1: *Means on Cover Crops Contributed to Watershed Management*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.40	1.056
Kibuon K2	70	3.74	.896
Kasipul K3	51	3.41	.942
Tende T1	148	3.23	.757
Isanta T2	47	3.49	.748
Mogusii T3	39	3.15	.933
Total	370	3.8	.681

The analysis had a statistically significant difference at F = 4.274 and p = 0.001on the level cover crops contributed to a reduction in watershed degradation in different sub catchments. Multiple comparison showed that Kibuon K2 was significantly different from Tende T1 (mean difference .513 significant at 0.000) and Kibuon K2 was also different from Mogusii T3 (Mean difference 0.589 significant at 0.007). This implied that Level of knowledge on management of watershedsusing cover crops was different in Kibuon K2, Tende T1 and Mogusii T3 (Table 121).

Table 2: *ANOVA Results on Cover Crops Contributed to Watershed Management*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	15.168	5	3.034	4.274	.001
Within Groups	258.335	364	.710		
Total	273.503	369			

Homogeneous sub sets were displayed in two levels. Mogusii T3 was significantly different from Kibuon K2 by few farmers being aware that cover crops contributed to watershed management compared to Kibuon K2 which reported more on cover crops contributing to watershed management. Tende T1, Kibuon K1, Kasipul K3 and Isanta T2 were not significantly different from any sub catchment. Kibuon K2 reported more on cover cropping contributing to watershed management than Isanta T2, Kasipul K3, Kibuon K1, Tende T1, and Mogusii T3 (Table122).

Table 3: *Tukey Post Hoc Results on Cover Crops Contributed to Watershed Management*

Sub catchment	N	1	2
Mogusii T3	39	3.15	
Tende T1	148	3.23	3.23
Kibuon K1	15	3.40	3.40
Kasipul K3	51	3.41	3.41
Isanta T2	47	3.49	3.49
Kibuon K2	70		3.74
Significant			

Kibuon K2 scored the highest on cover crops contributing to watershed management which was attributed to dissemination of soil and water conservation technologies during implementation of ILWMKTP project. To recall by respondents that cover crops contributed to watershed management depended on their level of knowledge which showed that many respondents had knowledge on cover crops contributing to watershed management in Kibuon K2. There were more affirming responses in Kibuon K2 followed by Isanta T2, then Kasipul K3. Kibuon K1 followed and lastly Mogusii T3 with the least mean of 3.15. Differences in their means indicated farmers' different levels of knowledge on cover crops contributing to watershed management. These findings agreed with a study by Mondal et al. (2013) on "Decomposition of Productivity growth in watershed: A study in Bundelkhand region of Mandhya Pradesh, India" which established that introduction of soil and water conservation technologies including cover crops increased cropping intensity and yield levels in watersheds. The findings were further confirmed by Mutuyimana (2015) in her study on "Effects of integrated soil and water management on livelihoods of smallholders in Burega sector, Rulindo district, Northern Province, Rwanda" in which he established that many farmers in Rwanda used cover crops because they controlled soil erosion effectively leading to improved yields.

Terraces Controlled Runoff Speed

Data was subjected to descriptive statistics; Kibuon K2 had the highest mean of 4.09 with a standard deviation of .830. Kasipul K3 had a mean of 3. 80 and 0.939 standard deviation, Kibuon K1 had mean of 3.73 and standard deviation of .884, Mogusii T3 followed with a mean of 3.59 and a standard deviation of 0.993. Isanta T2 had a mean of 3.55 and a standard deviation of .746 and the least mean was 3.43 for Tende T1 and a standard deviation of 0.842 (Table123).

Table 4: *Means on Terraces Controlled Runoff Speed*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.73	.884
Kibuon K2	70	4.09	.830
Kasipul K3	51	3.80	.939
Tende T1	148	3.43	.842
Isanta T2	47	3.55	.746
Mogusii T3	39	3.59	.993
Total	370	3.65	.890

The ANOVA test results indicated that there were significant differences at F- 5.986, significant at .000 on the level that terraces controlled watershed degradation in different sub catchments (Table 124). In multiple comparisons, the table showed that Kibuon K2 was significantly different from Tende T1 with a mean difference of 0.653 significant at .000 and Kibuon K2 was also found to be different from Isanta which had a mean of 5.33 significant at .014. This showed that the three sub catchments had different levels of knowledge on control of runoff speed by terraces.

Table 5: *ANOVA Test Results on Terraces Controlled Runoff Speed*

Variations	Sum of Squares	DF	Mean Square	F	Significant
Between groups	22.189	5	4.438	5.986	.000
Within Groups	269.836	364	.741		
Total	292.024	369			

Homogeneous sub sets were displayed in two columns. Tende T1 reported less (lower mean 3.43) on terraces controlled runoff speed compared to Kibuon K2 which reported high levels on control of runoff speed by terraces. Isanta T2, Mogusii T3, and Kibuon K1 and Kasipul K3 were not significantly different from any sub catchment. Tende T1 scored the least on terraces controlled runoff speed followed by Isanta T2, Mogusii T3, Kibuon K2 and Kasipul K3 (Table 125).

Table 6: *Tukey Post Hoc Results on Terraces Controlled Runoff Speed*

Sub catchment	N	1	2
Tende T1	148	3.43	
Isanta T2	47	3.55	3.55
Mogusii T3	39	3.59	3.59
Kibuon K1	15	3.73	3.73
Kasipul K3	51	3.73	3.73
Kibuon K2	70		4.09
Significant		.402	.072

Kibuon K2 had the highest mean on terraces controlling runoff speed followed by Kibuon K1 and Kasipul K3. Mogusii T3 was third followed by Isanta T2 and Tende T1. Fewer respondents in Tende T1 sub catchment had knowledge on terraces controlling runoff speed while Kibuon K2 had the highest number of respondents with knowledge on terraces controlling runoff speed. About 78 percent of key informants reported that respondents had knowledge on terraces which were used to control soil erosion and improve agricultural productivity. Dejene, Teressa and Guteta (2018) confirmed in their study on " The Effects of Community Based Watershed Management on Livelihood Resources for Climate Change Adaptation : The Case in Gemechis District, Oromiya." which established that terraces controlled runoff speed reducing soil erosion, improving moisture retention hence increased productivity. This agreed with findings by Govers et al. (2017) in their study on "Soil conservation in the 21st century: Why we need smart Agricultural intensification" which established that terraces were effective in controlling runoff speed thereby reducing soil erosion.

Contour Ploughing Controlled Watershed Degradation

Descriptive statistics presented the following results; Kibuon K2 had the highest mean of 3.80 and a standard deviation of 1.113. Kasipul K3 had a mean of 3.63 and a standard deviation of 1.038, Isanta T2 had a mean of 3.38 and standard deviation 0.898, Mogusii T3 got a mean of 3.36 and standard deviation of 0.989. Kibuon K1 had a mean of 3.33 and standard deviation 1.113. The least mean was for Tende T1 3.30 and standard deviation of 0.914 (Table 126).

Table 7: *Means on Contour Ploughing Controlled Watershed Degradation*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.33	1.113
Kibuon K2	70	3.80	1.016
Kasipul K3	51	3.63	1.038
Tende T1	148	3.30	.914
Isanta T2	47	3.38	.898
Mogusii T3	39	3.36	.989
Total	370	3.46	.979

ANOVA results indicated that there were statistically significant difference at F= 5.773 p = 0.010 on the level contour ploughing reducing watershed degradation in different sub catchments (Table 127). Multiple comparisons indicate Kibuon K2 and Tende T1 being significantly different with a mean difference of .503 significant at .005. This was an indication that level of knowledge on contour ploughing reducing watershed degradation was higher in K2 and lowest in Kibuon K1.

Table 8: *ANOVA Results on Contour Ploughing Controlled Watershed Degradation*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	14.354	5	2.871	5.773	0.010
Within Groups	339.455	364	.933		
Total	353.808	369			

One level of homogeneous sub set was displayed implying that all sub catchments had similar responses in relation to knowledge on control of watershed degradation through contour ploughing although Kibuon K2 had more responses on contour ploughing controlling watershed degradation while Tende T1 reported the least. All sub catchments had a lot of similarities. Kibuon K2 reported more controlled watershed degradation through contour ploughing compared to Kasipul K3, Isanta T2, Mogusii T3, Kibuon K1and Tende T1 (Table 128).

Table 9: *Tukey Post Hoc Results on Contour Ploughing Controlled Watershed Degradation*

Sub catchment	N	1
Tende T1	148	3.30
Kibuon K1	15	3.33
Mogusii T3	39	3.36
Isanta T2	47	3.38
Kasipul K3	51	3.63
Kibuon K2	70	3.80
Significant		0.198

Tukey post hoc indicated that Kibuon K2 had the highest level of knowledge on contour ploughing controlling watershed degradation compared to Kasipul K3, Isanta T2, Mogusii T3, Kibuon K1 and Tende T1. This may be associated with the ILWMKTP project that was implemented in the two catchments. Tende T1 had the lowest number of respondents who had knowledge on contour ploughing controlling watershed degradation. Although their means deferred, it was evident that the differences were not significant among sub catchments except for Kibuon K2 sub catchment. These confirmed that there were no wide gaps in their level of knowledge on contour ploughing controlling watershed degradation and increase crop and livestock productivity which was shared with Magombeyi, Taigbenu and Barron (2018) in their study on "Effectiveness of agricultural water management technologies on rain fed cereals crop yield and runoff in semi-arid catchment: a meta-analysis" which established that contour cropping improved soil fertility, control nutrient cycle, reduced soil erosion and increased productivity. This was shared by Dejene et al. (2018) in their study on " The Effects of Community Based Watershed Management on Livelihood Resources for Climate Change Adaptation the Case in Gemechis District, Oromiya." which established that 68.3 percent implemented contour ploughing in a catchment in Gemechis district to reduce soil erosion.

Check Dams Controlled Soil Erosion

Data was analyzed using descriptive statistics and various means and standard deviations were achieved. Kibuon K2 had a higher mean of 3.99 and standard deviation of 0.909 followed by Kasipul K3 with a mean of 3.75 and standard deviation of 0.997. Isanta T2 had a mean of 3.70 with a standard deviation of 0.749, Tende T1 had a mean of 3.69 and standard deviation of 0.772, Kibuon K1 had a mean of 3.47 and a standard deviation of 1.246 while Mogusii had a mean of 3.41 and a standard deviation of 1.163 (Table 129).

Table 10: *Means on Check Dams Controlled Soil Erosion*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.47	1.246
Kibuon K2	70	3.99	.909
Kasipul K3	51	3.75	.997
Tende T1	148	3.69	.772
Isanta T2	47	3.70	.749
Mogusii T3	39	3.41	1.163
Total	370	3.72	.906

The ANOVA results showed that there were significant differences at $F = 2.439$, $p = .034$ on the level at which check dams controlled degradation in different sub catchments. Multiple comparisons indicated significant mean difference between Kibuon K2 and Mogusii T3 with a mean difference of 0.575 significant at .018 (Table 130).

Table 11: *ANOVA Results on Check Dams Controlled Soil Erosion*

Variations	Sum of squares	DF	Mean square	F	Significant
Between groups	9.829	5	1.966	2.439	.034
Within Groups	293.374	364	.806		
Total	303.203	369			

Homogeneous sub sets displayed one column indicating that although scores may have been slightly different, it was not significant enough to display more than one column. Mogusii T3 reported less knowledge on check dams controlling soil erosion while Kibuon K2 had more knowledge on use of check dams in controlling watershed degradation. Mogusii T3 reported the least knowledge on check dams controlling soil erosion followed by Kibuon K1, Tende T1, Isanta T2, Kasipul K3 then Kibuon K2 (Table 131).

Table 12: *Tukey Post Hoc Results on Check Dams Controlled Soil Erosion*

Sub catchment	N	1
Mogusii T3	39	3.41
Kibuon K1	15	3.47
Tende T1	148	3.61
Isanta T2	47	3.70
Kasipul K3	51	3.75
Kibuon K2	70	3.99
Significant		.055

Kibuon K2 reported high level of knowledge on check dams controlling soil erosion followed by Kasipul K3 while Mogusii T3 reported less. About 80 percent of key informants reported that farmers had knowledge on control of soil erosion through use of check dam. These findings indicated that levels of knowledge on check dams controlling soil erosion varied within sub catchments although Kibuon K2 reported high levels of check dam use in gulley control and Mogusii T3 reported low levels. Respondents used the knowledge they had on check dams controlling soil erosion to improve land productivity in the watershed which was similar to findings by Adugna and Desta (2012) in their field guide on gulley control "A Field Guide on Gulley Prevention and Control" which established that check dams controlled runoff velocity encouraging sedimentation which improved agricultural land. This reflected in improved productivity confirmed by Dejene et al. (2018) on their findings on " The Effects of Community Based Watershed Management on Livelihood Resources for Climate Change Adaptation the Case in Gemechis District, Oromiya." which established that check dams reduced runoff speed in gullies encouraging siltation which increase agricultural land in the long run.

Grass Strips Reduced Runoff Flow

Through descriptive statistics the following means and standard deviations were determined; Kibuon K2 had a higher mean of 3.86 and a standard deviation of 1.107, Kasipul K3 had a mean of 3.86 with a standard deviation of 0.895. Kibuon K1 had a mean of 3.47 and a standard deviation of 0.834, Isanta had a mean of 3.40 and a standard deviation of 1.107 while Mogusii T3 had mean of 3.38 and a standard deviation of 0.935 (Table 132).

Table 13: *Means on Grass Strips Reduced Runoff Flow*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.47	.834
Kibuon K2	70	3.86	1.107
Kasipul K3	51	3.86	.895
Tende T1	148	3.26	.919
Isanta T2	47	3.40	1.107
Mogusii T3	39	3.38	.935
Total	370	3.49	1.002

Analysis of variance indicated that there were statistically significant differences at F = 5.348, p = 0.000 on the level at which established grass strips reduced runoff flow in different sub catchments. In multiple comparisons, Kibuon K2 and Tende T2 were significantly different with a mean difference of 0.600 significant at 0.000. Kasipul K3 was also significantly different from Kibuon K2 with a mean of 0.606 significant at 0.002. This indicated that level of knowledge on grass strips reducing runoff flow was different in the two pairs of sub catchments (Table 133).

Table 14: *ANOVA Test Results on Grass Strips Reduced Runoff Flow*

Variations	Sum of squares	df	Mean square	F	Significant
Between groups	25.352	5	5.070	5.348	.000
Within Groups	345.137	364	.948		
Total	370.489	369			

On homogenous sub sets, Kasipul K3 reported more knowledge on grass strips reducing runoff flow compared to Tende T1. Tende T1 had the least knowledge compared to Mogusii T3, Isanta T2, Kibuon K1, Kibuon K2 and Kasipul K3 (Table 134).

Table 15: *Tukey Post Hoc Analysis Results on Grass Strips Reduced Runoff Flow*

Sub catchment	N	1
Tende T1	148	3.26
Mogusii T3	39	3.26
Isanta T2	47	3.40
Kibuon K1	15	3.47
Kibuon K2	70	3.86
Kasipul K3	51	3.86
Significant		.069

Tukey post hoc tables showed that Kasipul K3 had more knowledge on grass strips reducing runoff flow which was followed by Kibuon K2, Kibuon K1, Isanta T2, Mogusii T3 and lastly Tende T1. This indicated that many respondents in Kasipul K3 and Kibuon K2 used grass strips to reduce runoff flow reflecting in less soil erosion. About 77.8 percent of key informants reported respondents using grass strips to control soil erosion in the six sub catchments. This was shared with Ghadiri, Hogarth and Calvin (2000) in their symposium proceeding on "The effectiveness of grass strips for the control of sediment and associated pollutant transport in runoff: The Role of Erosion and Sediment Transport in Nutrient and Contaminant Transfer" which established that grass strips controlled soil and water erosion due to the filtering effect, reduced runoff speed and enhanced soil deposition which translated in improved yields in maize, milk and forage. These findings were similar to research findings by Mutuyimana (2015) in her study on "Effects of integrated soil and water management on livelihoods of smallholders in Burega sector, Rulindo district, Northern province, Rwanda" which established that grass strips controlled land degradation through reduced soil erosion enhancing agricultural productivity.

Retention Ditches Increased Infiltration thereby Reducing Soil Erosion

Through descriptive statistics means and standard deviations were establish. Kibuon K2 had a highest mean of 4.06 with a standard deviation of 0.883, Tende T2 had a mean of 3.68 and a standard deviation of 0.849, Isanta T2 had a mean of 3.62 and a standard deviation of 0.848, Kibuon K1 had a mean of 3.60 and a standard deviation of 1.183, Mogusii T3 had a mean of 3.59 and a standard deviation of 0.966, Kasipul K3 had a mean of 3.57 and a standard deviation of 0.964. Many respondents in Kibuon K2 reported more knowledge on retention ditches increasing infiltration thereby reducing soil erosion while respondents from Kasipul K3 reported less knowledge (Table 135).

Table 16*: Means on Retention Ditches Increased Infiltration and Reduced Soil Erosion*

Sub catchment	N	Mean	Standard deviation
Kibuon K1	15	3.60	1.183
Kibuon K2	70	4.06	.883
Kasipul K3	51	3.57	.964
Tende T1	148	3.68	.849
Isanta T2	47	3.62	.848
Mogusii T3	39	3.59	.966
Total	370	3.72	.909

The analysis of variance indicated that there were significant differences at F= 2.646, p = .023 on the level at which retention ditches increased infiltration thereby reducing watershed degradation in different sub catchments (Table 136). Multiple comparisons showed that Kibuon K2 and Kasipul K3 were significantly different with a mean difference of .489 significant at .039 and Kibuon K2 was also different from Tende T1 with 0.375 mean significant at 0.049.

Table 17: *ANOVA Test Results on Retention Ditches Increasing Infiltration*

Variations	Sum of Squares	DF	Mean Square	F	Significant
Between groups	10.705	5	2.141	2.646	.023
Within Groups	294.498	364	.809		
Total	305.203	369			

Analysis produced homogeneous subset levels in one column. This showed that sub catchments had similarities in knowledge on retention ditches increasing infiltration thereby reducing soil erosion hence one subset level. There was more report on retention ditches increasing infiltration and reducing soil erosion from Kibuon K2 compared with Kasipul K3 sub catchment. Kasipul K3 reported less knowledge followed by Mogusii T3, Kibuon K1, Isanta T2, Tende T1 and Kibuon K2 (Table 137).

Table 18: *Tukey Post Hoc Results on Retention Ditches Increasing Infiltration*

Sub catchment	N	1
Kasipul K3	51	3.57
Mogusii T3	39	3.59
Kibuon K1	15	3.60
Isanta T2	47	3.62
Tende T1	148	3.68
Kibuon K2	70	4.06
Significant		.161

Kibuon K2 had a highest report of respondents with knowledge on retention ditches increasing infiltration thereby reducing soil erosion. It was followed by Tende T2, Isanta 2, Kibuon K1, Mogusii T3 and lastly Kasipul K3. The findings showed that many respondents in Kibuon K2 had knowledge on retention ditches increasing infiltration thereby reducing soil erosion while the least number of respondents with that knowledge were from Kasipul K3. About 70 percent of key informants reported that respondents had knowledge on retention ditches increasing infiltration thereby reducing soil erosion. These agreed with findings by Magombeyi, Taigbenu and Barron (2018) in their study on "Effectiveness of agricultural water management technologies on rain fed cereals crop yield and runoff in semi-arid catchment: a meta-analysis" which reported that retention ditches were effective in slowing down runoff speed, enhancing sedimentation, infiltration, soil fertility and improved productivity. This was shared with Dollinger, Dagès, Bailly, Lagacherie and Voltz (2015) in their study on "Managing ditches for agro ecological engineering of landscape." which reported retention ditches retaining water and releasing it slowly directly into the soil reducing soil erosion.

Summary for Sub Catchments on Level of Knowledge on Watershed Management Technologies

Sub catchments were ranked basing on their mean values in Tukey post hoc tables starting with the highest rank (1) to the lowest (6). Kibuon K2 had the highest level of knowledge on watershed management technologies by ranking first in 5 technologies in column 1; Kasipul K3 ranked first in 3 technologies in column 2; Isanta T2 was ranked first in 3 technologies in column 3; Kibuon K1 and Mogusii T3 were each ranked 1 in two technologies each in column 4. In column 5 Kibuon K1 and Mogusii T3 were ranked first in two technologies each. Tende T1 was ranked first in 3 technologies in column 6 (Table 138).

Table 19: *Ranked Levels of Knowledge for Sub Catchments on Watershed Technologies Promoted in the Catchments*

Variable	1	2	3	4	5	6
Cover cropping contributes to watershed management	Kibuon K2	Isanta T2	Kasipul K3	Kibuon K1	Tende T1	Mogusii T3
Terraces control runoff speed	Kibuon K2	Kasipul K3	Kibuon K1	Mogusii T3	Isanta T2	Tende T1
Contour ploughing controls watershed degradation	Kibuon K2	Kasipul K3	Isanta T2	Mogusii T3	Kibuon K1	Tende T1
Check dams control soil erosion	Kibuon K2	Kasipul K3	Isanta T2	Tende T1	Kibuon K1	Mogusii T3
Grass strips reduce runoff flow	Kasipul K3	Kibuon K2	Kibuon K1	Isanta T2	Mogusii T3	Tende T1
Retention ditches increase infiltration thereby reducing soil erosion	Kibuon K2	Tende T1	Isanta T2	Kibuon K1	Mogusii T3	Kasipul K3

Summary of Sub catchment Positions on Levels of Knowledge on Soil and Water Conservation Technologies

Data on level of knowledge on watershed management technologies promoted in the catchments was analyzed and results indicated that Kibuon K2 sub catchment had the highest level of knowledge in 5technologies that controlled watershed degradation followed by Kasipul K3 sub catchment. The third sub catchment was Isanta T1, Kibuon K1 and Mogusii T3 were number 4 while Tende T1was 6 in level of knowledge on watershed management technologies. The findings indicated that the levels of knowledge in the sub catchments were significantly different (Table 139).

Table 20: *Summary for Sub Catchment Positions on Levels of Knowledge on Soil and Water Conservation Technologies*

Sub catchment	Positions attained	Number of technologies	Ranks	Final position
Kibuon K1	1	2	4	4
Kibuon K2	1	5	1	1
Kasipul K3	1	3	2	2
Mogusii T3	1	2	4	4
Isanta T2	1	3	3	3
Tende T1	1	3	6	6

Frequency Table for Responses on Soil and Watershed Management Technologies

A frequency table for those who agreed to positive statements on soil and water conservation technologies ranged from 39.2 to 71.3 percent. The findings on knowledge and skills, and attitude on different watershed management technologies showed various levels which were an indication of significant differences in knowledge and skills, and attitude of the respondents on watershed management technologies hence (Table 140).

Table 140: *Frequency of Respondents who Agreed to the Positive Statements on Watershed Management Technologies*

Technology	SD	D	N	A	SA	Total (Agreed)
Cover cropping contributed to watershed management	1.6	8.9	50.3	27.8	11.4	39.2
Terracing controlled runoff speed	1.4	7.8	31.4	43.2	16.2	59.4
Contour ploughing controlled watershed degradation	3.8	11.1	33.8	38.4	13	51.4
Check dams controlled soil erosion	3.2	6.2	21.1	54.6	14.9	69.5
Grass strips reduced runoff speed	3.8	10.8	33	37	15.4	52.4
Retention ditches increased infiltration	2.7	8.6	17.3	57	14.3	71.3

IV. Discussion

Farmers' Level of Knowledge on Watershed Management Technologies

Dataon farmers' knowledge on watershed management technologies was measured on a five point likert scale and analyzed using Analysis of variance and frequency. The methods were applied on: cover cropping contributed to watershed management, terraces controlled runoff speed, contour ploughing controlled watershed degradation, check dams controlled soil erosion, grass strips reduced runoff flow and retention ditches increased infiltration thereby reducing soil erosion. The findings indicated that Kibuon K2 had the highest level of knowledge on watershed management technologies compared to Kasipul K3, Isanta T2, Kibuon K1, Mogusii T3 and Tende T1sub catchments. Frequency table showing those who agreed to positive statements on watershed management technologies showed that above 50 percent of respondents agreed on all the technologies; terracing, contour ploughing, check dams, grass strips and retention ditches controlling watershed degradation except cover cropping which had 39.2 percent.

V. Conclusion

Despite the fact that respondents were taken through same trainings on technology construction, establishment and use of watershed management technologies, there were still variations in levels of knowledge on the technologies controlling watershed degradation. This indicated that despite exposure to same knowledge, the levels varied from one sub catchment to the other hence variations in uptake of the technologies.

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