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Full Length Research

Assessment of Water and Soil Management Approaches for Small-Scale Dry Land Farming in Kitui and Makueni Counties, Kenya

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Water is a scarce commodity in the Arid and Semi-arid Land (ASAL) of Eastern Kenya. In this study, an assessment of household water and soil management technologies in Kitui Central, Mulala and Wote Locations is presented. A purposive sampling procedure was used in selecting the locations based on agro-ecological setting. For each location, random sampling procedure was employed in selecting and interviewing households. The findings showed that in Kitui Central, Wote and Mulala locations, loam soils represent 60%, 47% and 43% by composition, respectively. Fertility of the soil is mainly maintained by use of organic manures and inorganic fertilizers. Organic manure was more dominant in Kitui central and Wote locations each with 52% compared to Mulala with 48.5% of the total households in each. On average, water consumption was found to be 21 litres/capita day for people and 80 litres/animal.day for the livestock. Water harvesting technologies adopted by households were roof catchments, earth dams, sand dams and micro/macro-catchments at 38.4%, 22.3%, 14.2% and 11.5%, respectively within entire study area. Soil conservation in these areas mainly use terracing (53.3%) and planting trees (28%). Public tap dominate the water supply sources with Kitui Central division taking approximately 56% and Wote 22.5%. Protected well and rainwater harvesting sources supply 2.2% of the households in the Wote division insignificant values for Kitui Central and Wote divisions. The findings showed the need to mobilize funds for development of water resources and soil conservation to accelerate socio-economic development and increase food security in the study areas. There is need to train households for proper design, layout and sustainable soil and water conservation technologies.

Keywords: ASAL, Organic manure, Terracing, Food security, Socio-economic

INTRODUCTION

Soil and water conservation is a critical practice in agricultural production. It is a practice used for maintaining soil fertility. According to Muhlbachova et al. (2016), soil fertility is a prerequisite for achieving adequate and quality production. Any successful conservation should aim at reversing and preventing land degradation based on sustainable land management (SLM) concept where the use of resources should meet the present and future generations (Baptista et al., 2015). According to Tilahun and Teferie (2015), soil and water conservation refers to the combination of proper land use and management practices that supports productivity and sustainable use of land and water while at the same time minimizing land degradation. The purpose of conducting soil and water management research is to increase the period of water availability, alleviate water scarcity in drought period, increase crop water productivity, and improve water and soil quality, preserve soil and water resources and provide a framework for sustainable soil management (FAO, 2015). The current state in research and science should focus on providing solutions to the present and future food insecurity within arid and semi-arid lands (ASAL) and other agricultural areas. This depends upon the extent of water and soil resources management at present and in the future (Delgado, et al., 2011).

Sustainable soil and water management is fundamental to food security and nutrition in any region (FAO 2015). The challenges of food insecurity can be addressed by maximizing soil and water conservation to develop sustainable systems essential to mitigate climate change and its adaptation. Some of the soil and water conservation approaches that can be used to mitigate climate change include prevention of soil erosion against extreme weather events, use of high efficiency irrigation systems that conserve water quantity and quality, development of crop varieties that are drought-tolerant/resistant to heat stress and application precision conservation of soil and water (Delgado et al., 2011)

Soil and water conservation research leads to proper understanding of soil-water-crop relation for the purpose of controlling water flux in soil water system (USDA-ARS, 2011). Within dry land environments, soil erosion is rampant especially on steep slopes. Unlike the natural soil erosion, accelerated erosion causes significant land degradation that adversely affects agricultural production. Some of the characteristics of soil degradation include surface-water quality, soil and organic matter decline (Tong and Chen, 2002). For instance, average soil moisture content was found to be 8.9% and 13.5% while the organic matter content was 3.17% and 5.5% for degraded and non-degraded soils respectively (Tafangenyasha et al., 2011). On the agricultural lands, spatial land degradation deviates from one point to the other. In this respect, spatially distributed data give risk areas on human-induced soil erosion as critical in design, layout and installation of conservation structures (Wambua et al., 2009).

The promotion of agricultural production in the smallholder sector requires increased investment in irrigation systems that are sustainable and that more effectively manage increasingly scarce water resources. Small-scale irrigation systems, involving water capture at the micro-watershed level and the sustainable use of some wetlands, could significantly increase staple crop production and help to ensure food security year-round in areas where they can be developed.

Due to the recurrent droughts, exposure of bare soils, climate change and erratic rainfall in ASALs, these areas are prone to soil and water degradation and food insecurity. Thus there is need to focus on soil and water conservation to minimize on land degradation and improve on the food security in the dry lands (Delgado et al., 2011).

Objective

The main objective of this study was to assessment water and soil management approaches for small-scale dry land farming adopted and/or adapted for selected dry land areas in Kitui and Makueni counties, Kenya

The Study Area

The study was conducted in Kitui Central, Mulala and Wote Divisions in former Kitui, Nzaui and Makueni Districts respectively. The three areas are located in the semi-arid zones of South Eastern Kenya and experience two rainy seasons, namely: the long rains occurring in March to April while the short rains occur in November to December and the rest of the year is hot and dry shown in figure 1.

The soil types in the area range from red sandy soils in the eastern parts, to clay black cotton soils which are generally low in fertility. The abundant sandy soils and clay soils are exploited on commercial basis for building sand and brick making in areas where they occur. About 90% of Kitui's population live in the rural areas, therefore solid waste management is not a major challenge. However, human activities such as clearing of land for agriculture, settlements, charcoal burning and cutting of indigenous trees for carving have put the district at a crucial state of desertification. Perhaps of most serious consequence is the felling of trees for charcoal production that has reached commercial levels. The district produces nearly 300,000 bags of charcoal annually causing loss of biodiversity and severe land degradation in the fragile ecosystem. The most affected region is northern Yatta (Kwa-Vonza, Southern Yatta), Kitui South and Kitui East. There is urgent need to curb the felling of trees to protect livelihoods in the district. The districts' population is largely rural-based with only 10% residing in the urban areas. The settlement patterns are greatly influenced by climate and water availability and the most densely populated division is Kitui Central with 153 persons per square Kilometer.

On the other hand, Makueni Sub-County borders Nzaui to the West, Kibwezi to the South, Kitui to the East and Machakos to the North. It covers an area of

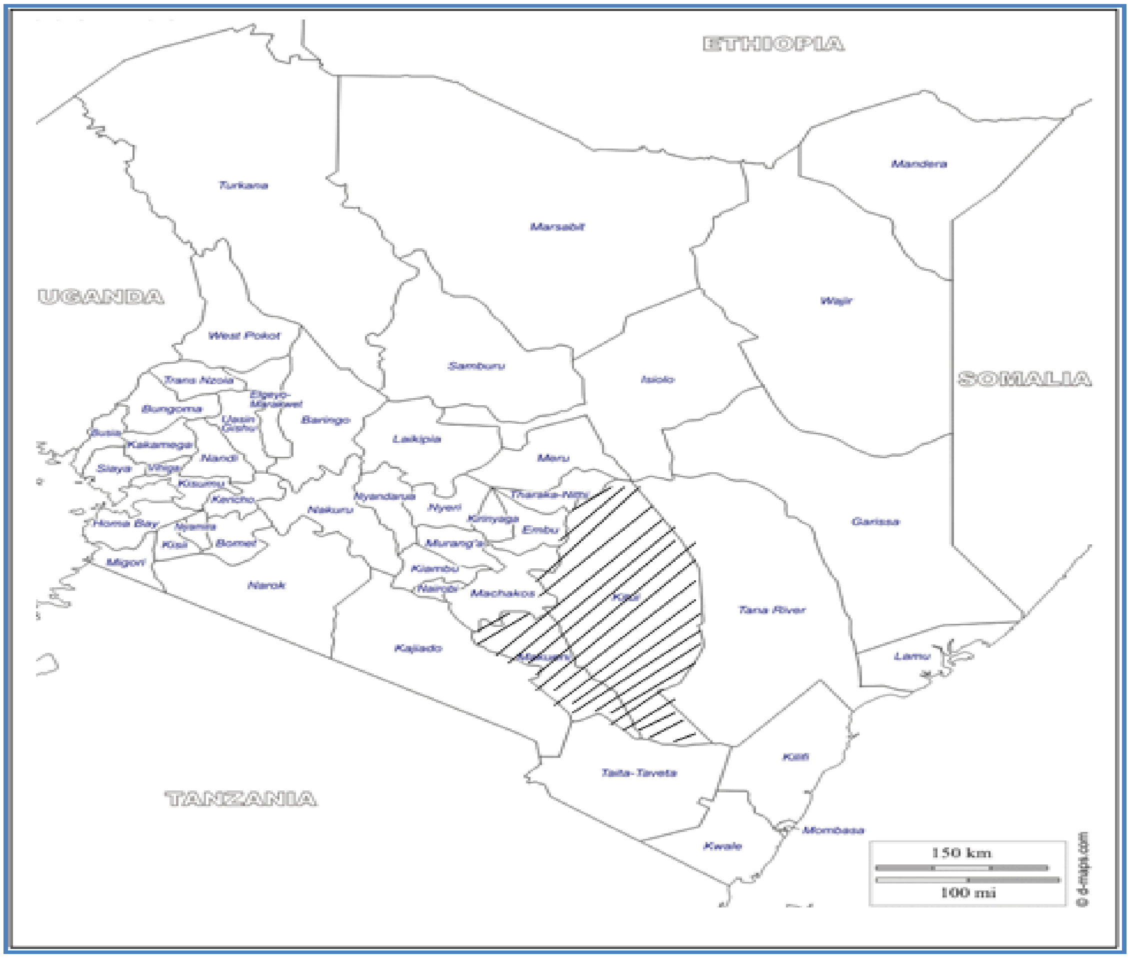

Figure 1: Map of Kenya showing the (shaded) study area

approximately 1699.4 Km² and comprises of eight divisions, twenty four locations and fifty four sub-locations. It is generally a low-lying, rising from about 500m above sea level at the lowlands of Kathonzweni and Wote Division to 1,800 m above sea level on Kilungu hills. The hills are of granite rocks formation and are situated to the North West of the Sub-County. The southern part is low lying grassland, which receives little rainfall but has an enormous potential for ranching and dry-land agriculture. The northern part is hilly with medium rainfall ranging from 800 mm to 1200mm and has high potential for food crop production. This part of the Sub-county, mainly Kilungu and Kaiti divisions, has few natural and planted forests. These divisions are suitable for horticulture and dairy farming. The Sub-county is usually prone to frequent droughts that are normally experienced on the lower side of the district which are usually very dry and receives very little amount of rainfall mainly ranging from 300mm to 400mm which is hardly enough to sustain any kind of crop and the main economic activity undertaken by the local people is livestock rearing. Drought is a major cause of poverty in the district and the most vulnerable are women, children, the aged and the disabled. Many families lose their livestock during prolonged drought and water is accessible from very far. Money meant for gainful development activities is spent on providing relief food for the people during drought period. This has impacted negatively on the efforts being made to reduce poverty in the district. (Makueni District Development Plan 2008-2012).

Nzaui Sub-County (Figure 2) borders Kajiado to the West and the South, Makueni Sub-County to the North and the East, Kibwezi to the South East and Machakos to the North West. It covers an area of 1,412.6 Km² and comprises of five (5) divisions, twenty five (25) locations and sixty seven (67) sub locations. It has two population patterns, the highly populated hilly masses of Kilome division, some parts of Kasikeu and Mbitini divisions and the sparsely populated lower lands of Nguu and Matiliku divisions and the remaining parts of Mbitini and Kasikeu. The highest population density is in Kilome division with 344 persons per square kilometer and the lowest is in Nguu division with 73 persons per square Kilometer.

The Sub-County is generally a low-lying, rising from about 300m above sea level at the lowlands of Nguu division to 1,100m above sea level in Kilome hills. The hills are of granite rocks formation and are situated to the North West of the District. The Nzaui Hill (from which the district derives its name) is higher though it is not as wet as the Kilome Hills. The south eastern part of the district is low lying grassland, which receives little rainfall but has an enormous potential for ranching. The North western part of the district is hilly with medium rainfall averaging 720 mm and has a potential for food and cash crop production. This area has a number of natural and planted forests and the divisions falling in this area are suitable for coffee, horticulture and dairy farming. The hilly parts of the district receive about 680-720 mm of rainfall per year. The high temperature experienced in the low-lying areas is responsible for high evaporation and frequent droughts that are normally worse on the lower side of the district. The lower part of the district is usually dry and receives little amount of rainfall averaging 355 mm which is hardly enough to sustain crop production. The only viable activity is livestock rearing (Nzaui District Development Plan 2008-2012).

METHODOLOGY

Methods of data collection and analysis

The data used in this study was derived from two main sources, primary and secondary. In the former approach, the following techniques in data collection were applied: Observation by the researchers recorded by use of a camera and field notebook, Interactive participatory approach through personal or informal interviews on topics related to the study whereby short notes were taken. These were in form of Focused Group Discussion (FGDs) drawn to represent women, youth and men from different sub-locations with the help of local leaders. Then recording questionnaires or schedules on water conservation, domestic water and agricultural water use were carried out. The Secondary sources used the relevant secondary data sources for this study entailed: published and unpublished works on studies previously done on the topic; government publications such as Statistical Abstracts, Development Plans, Economic Surveys, Maps, and Socio-Cultural Profile Reports, Parastatal Annual Reports, Journals, Magazines and Internet. The data was entered into MS Excel spreadsheet, and analyzed to generate frequency tables, graphs and charts.

RESULTS AND DISCUSSIONS

Number of Households Interviewed

In the present study, the table 1 shows the breakdown of the total number of househols interviewed per location.

Table 1: Distribution of total number of households interviewed in each location

Name of Location	Name of the County	Number of households interviewed
Kitui central	Kitui	109
Mulala	Makueni	264
Wote	Makueni	130
Total		**503**

The households were purposefully selected from different sub-locations within each location. The distribution of the number of households interviewed per sub-location in Kitui Central, Mulala and Wote locations is as shown in Figures 2, 3 and 4.

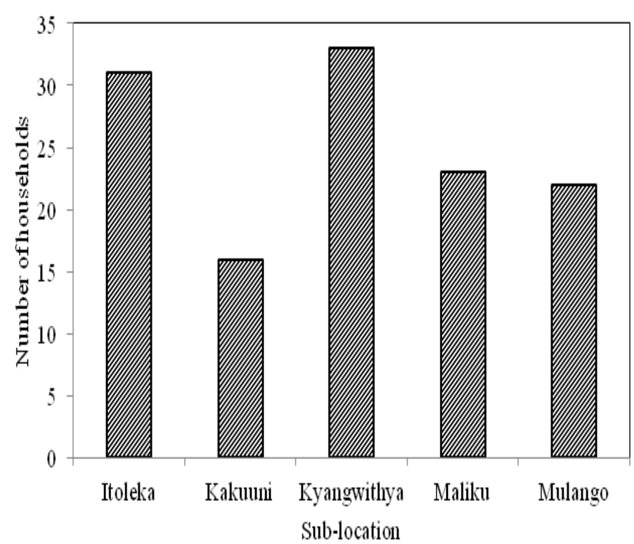

Figure 2: Number of households interviewed per sub-location in Kitui Central Location

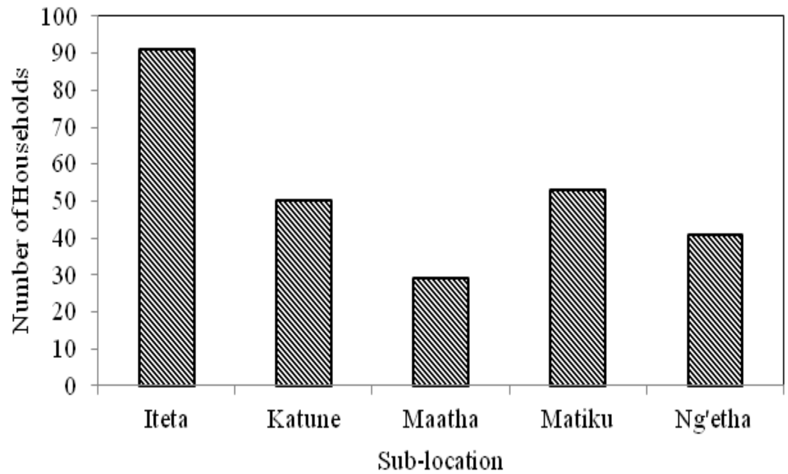

Figure 3: Number of households interviewed per sub-location in Mulala Location

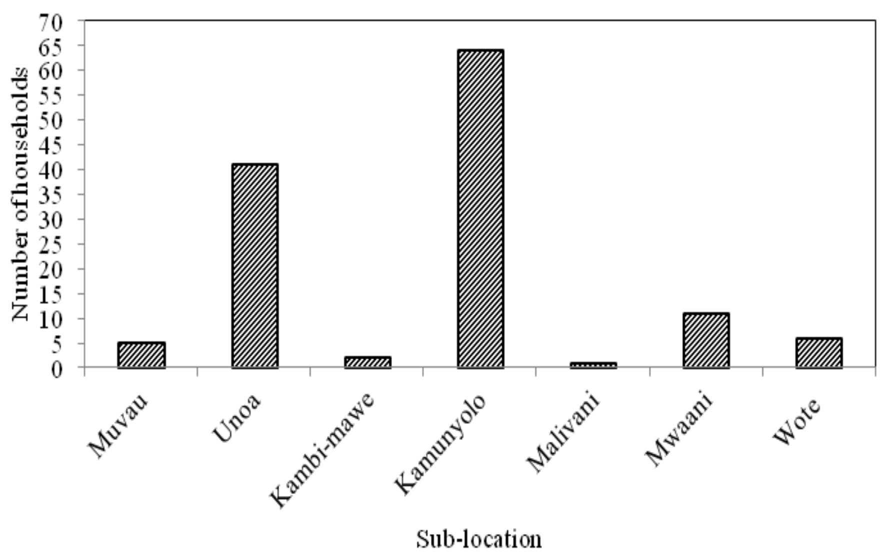

Figure 4: Number of households interviewed per sub-location in Wote Location

Socio-Economic Characteristics of the Households

Out of the interviewed households, forty eight percent of the households were headed by persons aged between 41 and 60 years, while 36% and 15% were headed by persons aged between 21 and 40 years and above 61 years, respectively. One percent of the households were headed by persons below 20 years of age (Figure 1). Generally, the highest levels of education achieved are primary school (39.4%), secondary (25.2%), tertiary (15.1%) and adult education (11.9%), across all the three divisions. In Kitui Central, 46.8% of the households are female-headed while in Mulala and Wote Divisions, 76.9% and 80% respectively, are headed by females (Figure 5). Fifty five percent of the households in Kitui Central have permanent houses while in Mulala and Wote Divisions have 62.5% and 84.6%, respectively.

Besides, the gender of the household head also influences the type of decisions made. Men tend to shun

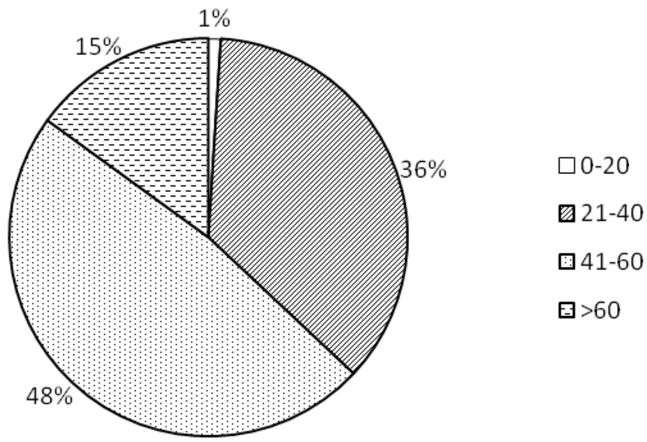

Figure 5: Age Categories of Household Heads

Table 1: Socio-Economic Characteristics of the Selected Households

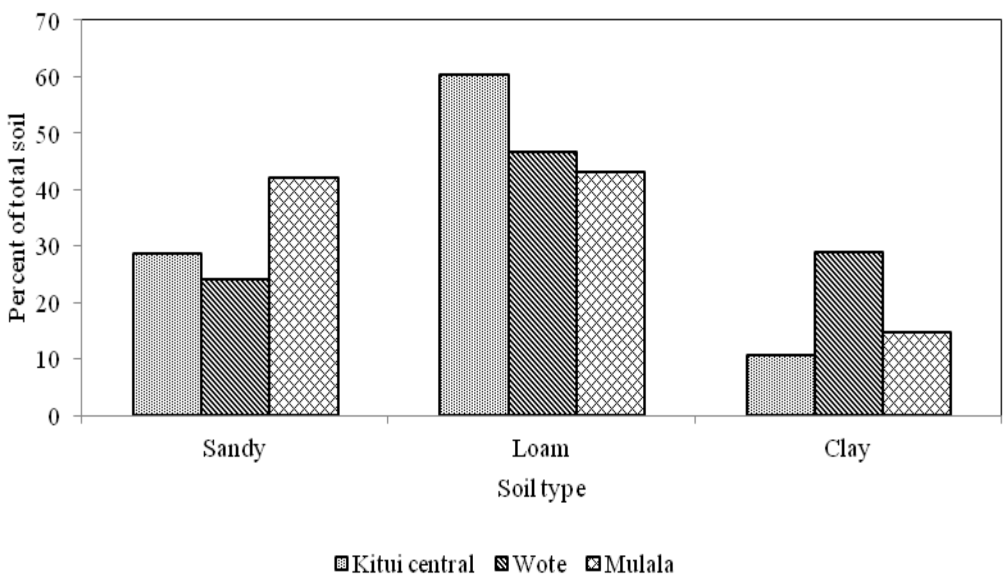

Figure 6: Percent (%) soil types of soil found in Kitui Central, Mulala and Wote Divisions

responsibility or migrate from home in search of jobs. Men also die early due to natural attrition. This might explain the reasons why 76.9% and 80% were headed by females in Mulala and Wote divisions respectively.
Housing type is an indicator of levels of income/wealth with permanent houses depicting higher incomes while grass thatched houses depicts poverty.

Soil Types and Fertility Management

All types of soils exist in all the study areas (Figure 6). Loam soil constitutes the bulk of the soil in all the three divisions. Kitui Central (11%) clay soil is least followed by Mulala (15%) and Wote (29%) has the most. A large proportion of sandy soil is in Mulala (42%),

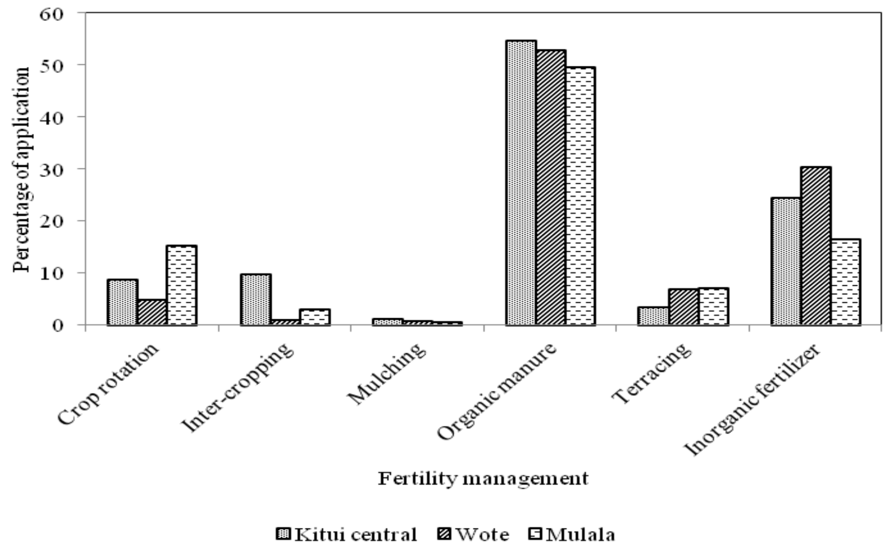

Figure 7: Soil Fertility Management in Kitui Central, Wote and Mulala Divisions

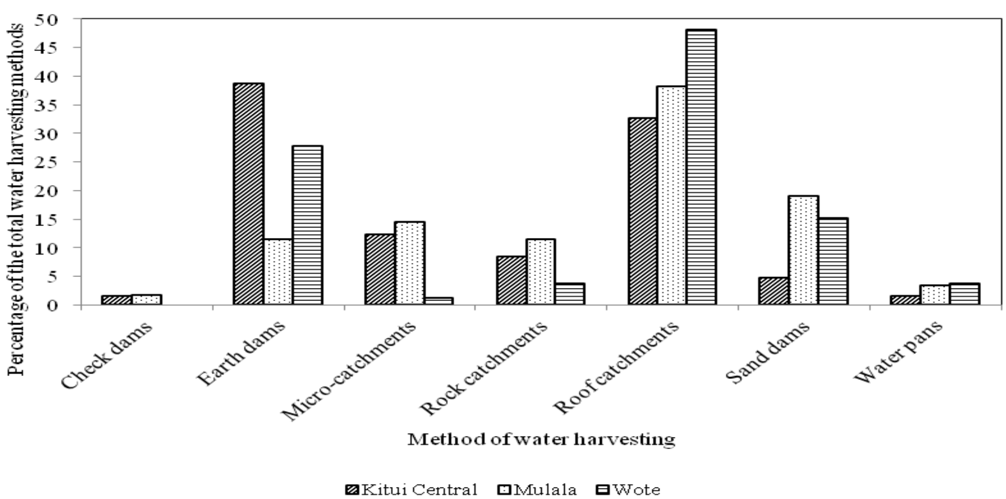

Figure 8: Water harvesting methods by percent in Kitui Central, Wote and Mulala Locations

followed by Kitui Central (29%) and Wote (24%) has the least. Kitui Central (60%) has the greatest amount of loam soils, followed by Wote (47%) and the least is in Mulala (43%).

Fertility of the soil is maintained by mainly organic manures and inorganic fertilizers (Figure 7). Others are crop rotation and intercropping. It is in Kitui Central that maintenance of soil fertility is minimal. Mulala uses a combination of methods to maintain fertility (control of soil erosion, fallowing, mulching, planted trees and terracing).

Rain Water Harvesting Technologies

The water harvesting methods were analyzed and presented as percentage of the total number of methods used by all the households in each Location as shown in Figure 8. Rainwater is mainly harvested using roof catchments (38.4%) and earth dams (22.3%). Sand dams (14.2%) and micro/macro-catchments (11.5%) are also found in many areas. Rock catchments, water pans and check dams contribute a significant amount of harvested water. The most popular rainwater harvesting

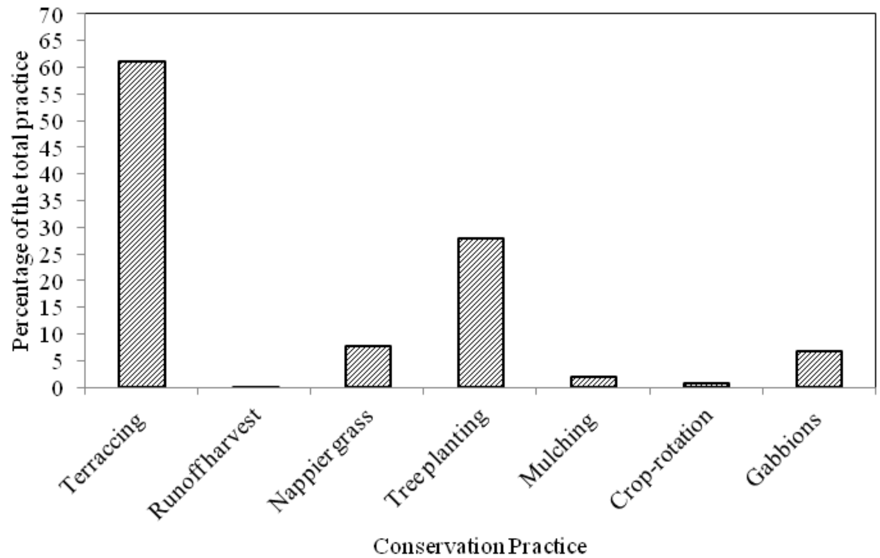

Figure 9: Percent Soil and Water Conservation Measures Practiced in the Study Area

Table 2: Sources of Water for the Households (%)

Main source of water dry season	Kitui Central	Mulala	Wote	Overall
Bottled water	0	0.0	2.9	0.5
Open public well	4	11.5	4.3	8.6
Open well in dwelling/yard/plot	8	2.0	1.4	3.3
Piped into dwelling	0	0.0	8.7	1.4
Piped into yard/plot	1	0.0	0.0	0.2
Pond/lake/dam	14	7.1	13.0	9.7
Protected public well	0	1.2	0.0	0.7
Protected well in dwelling/yard/plot	0	0.8	1.4	0.7
Public tap	56	55.2	23.2	50.1
Rain water	0	0.4	1.4	0.5
Spring/river/stream	17	21.8	43.5	24.2

system include roof catchment (38.4%), followed by earth dams (22%), % sand dams (14.2). the least technology is check dams (1.4). Therefore, most of the houses have roofs made of corrugated iron sheets. Mulala is more of a rural area and hence the households have houses whose roofs are made of thatch.

Soil and Water Conservation Structures

A number of soil conservation structures are found in all the study areas (Figure 9). The ones used in most cases are, terracing (53.3%) and planting trees (28%). The rest of the soil conservation structures are not significant. The structures that are prevalent are not as costly and labour intensive as the rest.

Water for Domestic and Agricultural Use

The main source of water in Kitui central and Mulala is public tap while in Wote is spring/river/stream. Rain water is hardly used in all the three divisions. There is no division where most of the households have water piped into yard/plot (Table 2).

From the Focus Group Discussions, it was reported that about 1% of the farmers in Wote practiced irrigated small scale agriculture. In Kitui Central and Mulala field

Table 3: Daily Average amount of Water Used by Households in the Study Areas

Water consumption	Kitui Central	Mulala	Wote
Consumption per capita per day (l/capita. Day)	22.3	16.9	21.2
Water for animals (20-litre Jerican)	3.3	4.8	3.3

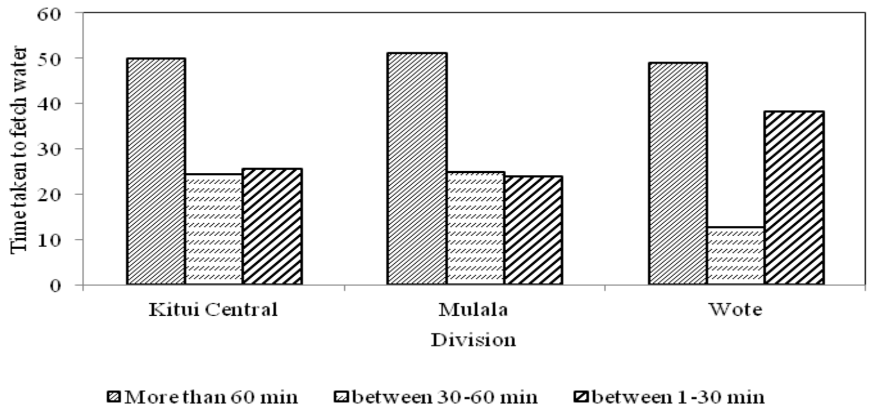

Figure 10: Time Taken to Fetch Water during Dry Season in the Study Areas

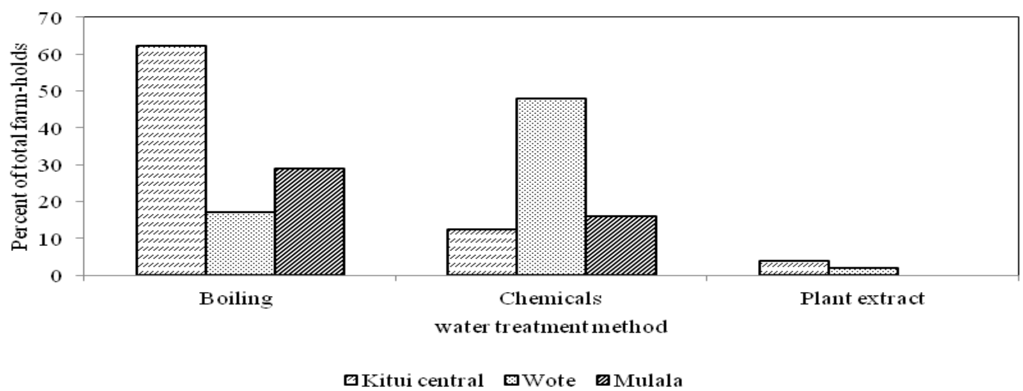

Figure 11: Percent (%) Water Treatment Technologies in the Study Areas

observations revealed that irrigation was practiced along the river banks and in the vicinity of shallow wells. On average, the amount of water used per person in all the divisions in litres per capita per day, and that for animals expressed in 20-litre jericans per animal per day is presented in Table 3.

On average 50% of the households take up to 30 minutes walking to fetch water. In Wote 38.2% households take more than 60 minutes walking to fetch water while in Mulala and Kitui Central 25% of the households take more than 60 minutes (Figure 10).

In Kitui Central, 62.3%, 3.9% and 2.6% of households treat their water by boiling, plant extracts and chemicals, respectively, while 31.2% do not treat water at all. As for Wote, treatment is by use of chemicals (48.1%), boiling (17.3%), plant extracts (1.9%) whereas 32.7% do not treat their water. The statistics for Mulala are 16.2% and 28.9% for chemicals and boiling respectively. Fifty five percent of the households in Mulala do not treat their water (Figure 11).

CONCLUSION AND RECOMMENDATIONS

Within the three divisions, main soil type is sandy-loam. To conserve the soil in the farms, terraces have been utilized. The soil is also conserved through fertility management by using organic manure, cultural practices such as crop rotation, mulching, and mixed cropping. The most commonly utilized water is from conservation structures such as small earth dams, the roof and sand dams. A few earth and sand dams within the divisions are used to supply water for domestic and agriculture purpose. However, roof catchment is used mainly for domestic water utilization. Check dams and water pans provide the least amount of water in the divisions.

It is recommended that more research on the effect of on-farm soil and water conservation on soil-moisture regime of crop root zone, bulk density, porosity and correlate the variables with seasons. For purposes of improving food security in ASAL, farmers should be trained on proper design, layout and utilization of soil and water conservation structures, rainwater harvesting, water treatment technologies, Adoption of high-water use efficiency technologies at farm level, conservation tillage, and construction of large community-based earth dams to harvest runoff to increase water availability.

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