Soil And Water Conservation Review In Rombo And Mondabogho Watersheds In Kajiado And Taita Taveta Counties, Kenya

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***Abstract*—Land degradation adversely affect agro-ecosystems and agricultural productivity, resulting in food insecuries. It also plays a role in accelerating climate change effects. There has been a critical on-site and off-site land degradation structures in selected Arid and Semi-arid Lands (ASALs) of Kenya. Such ASAL areas include Rombo and Mondambogho watersheds in Kajiado and Taita Taveta Counties respectively, and this has subsequently resulted in a decline in land productivity. The interaction of continuous land cultivation, over-grazing and influence of climate change without appropriate soil and water conservation (SWC) has accelerated the problem. This paper presents a critical review of land degradation alongside soil and water conservation in the two watersheds. The objective of this research was to evaluate the status of SWC practices in the two watersheds. It was found that the two watersheds experience both on-site and off-site soil erosion due to poor agricultural land use practices. As such viable research and solutions needed for sustainable soil and water conservation are highlighted. It is recommended that mechanized SWC techniques should be employed for the two case studies for increased land productivity, food and nutritional security in these areas.**

Keywords—ASALs, Sustainable SWC, On-site land degradation, Rombo, Wondabogho watersheds, mechanized SWC)

INTRODUCTION

Globally there has been crucial challenges affecting humankind caused by land degradation. More than 3.2 million people experience socio-economic and health problems associated with the degradation (Chalise et al., 2019; Kertesz and Krecek 2019). Accelerated human-induced soil erosion is a critical hazard that adversely affect sustainability of agricultural production and agro-ecosystems across the globe (Teng et al., 2016; Rodrigo et al., 2018; Chalise et al., 2019). According to United Nations (2021) report, up to 65% of productive Africa's land is degraded with an estimated 132 million hectares of degraded cropland, which combined with climate change, makes millions more vulnerable. Degraded croplands results in low crop yields leading to food insecurity. Crop production in most of the ASALs of Kenya depend on rain fed agriculture. Due to low rainfall in these areas, runoff soil erosion, sediment deposition compounded by the climate change and variability, the crop yield in such areas has continued to decline (Agesa et al., 2019; Obwocha et al., 2022). There is need to have a sustainable land productivity for reliable food security in those areas. Thus effective soil and water conservation in the ASALs is very important for increased land productivity. This can directly or indirectly accelerate the

achievement of United Nations' Sustainable Development goals (SDGs), . Pparticularly SDG 2 which is on Zero hunger and focuses on establishing sustainable food production systems (Keesstra et al., 2018; Visser et al., 2019; Marenya et al., 2022). When agricultural land is used over long period of time without practicing soil and water conservation, land degradation occurs and significantly reduces crop production. According to UN SDG 15 which is about lLife on land, . Thisthe goal calls for protection, restoration, promotion and sustainable use of terrestrial ecosystems. This goal can be achieved via design and layout of soil and water conservation structures on agricultural fields.

Generally there has been a reduction in land productivity within Rombo and Mondabogho Watersheds in Kajiado and Taita Taveta counties respectively. These areas are located in ASALs of Kenya which is for has a fragile ecosystem with poor land management practices. Continuously agricultural production without proper soil and water conservation lead to soil erosion such as; rill, gully, sheet, inter-rill and splash erosion. The subsequent impacts of this are decline in soil fertility, low crop yield and decreased pasture production and food insecurity (Pimentel and Burgess, 2013). One of the crucial steps in accounting for the sediment budget within a watershed is the estimation of the soil erosion (Eisenberg and Muvundja, 2020). Since soil erosion may take place on the surface and within channels, models that describe the soil loss overland and in channel processes may be adopted and adapted to specific watersheds (Yin, et al., 2020). The assessment of soil and water conservation structures on specific sites of watersheds is
limited. Field data coupled with modeling approaches may be applied to achieve this.. For instance the effectiveness of soil and water conservation structures for soil erosion control may be conducted using semi-distributed models (Nabi, et al., 2020).

Objective: This article aimed at investigating the present status of land degradation with a view to exploring effective methods of soil and water conservation through following

(i) Review of soil and water conservation nexus in Kajiado county and
(ii) Explore the possibilities of mechanized SWC to maintain soil fertility for sustainable agricultural production ASALs
(iii) Highlight and recommend alternative ways of addressing SWC to meet the needs of farmers within the two watersheds

1.2 STUDY AREAS

1.2.1 ROMBO WATERSHED

Rombo watershed is located in Kajiado County and lies within the latitudes 3°0'and 3°4'S, and longitudes 37°37' and 37°42' E. Rombo watershed covers an area of 19.3 km^2, average slope of 3.2%, with highest and lowest elevation of 1486.8 and 1191.6 m asl respectively. The hydrologic divide of Rombo watershed has a perimeter of approximately 119 km and covers the following main villages; Enchurrai, Munyurra, Maroroi and Enduet with sparse population. A baseline survey using a questionnaires was conducted within Rombo for a number of sampled house-hold (HH) respondents distributed in different locations of the study area (Figure 1)

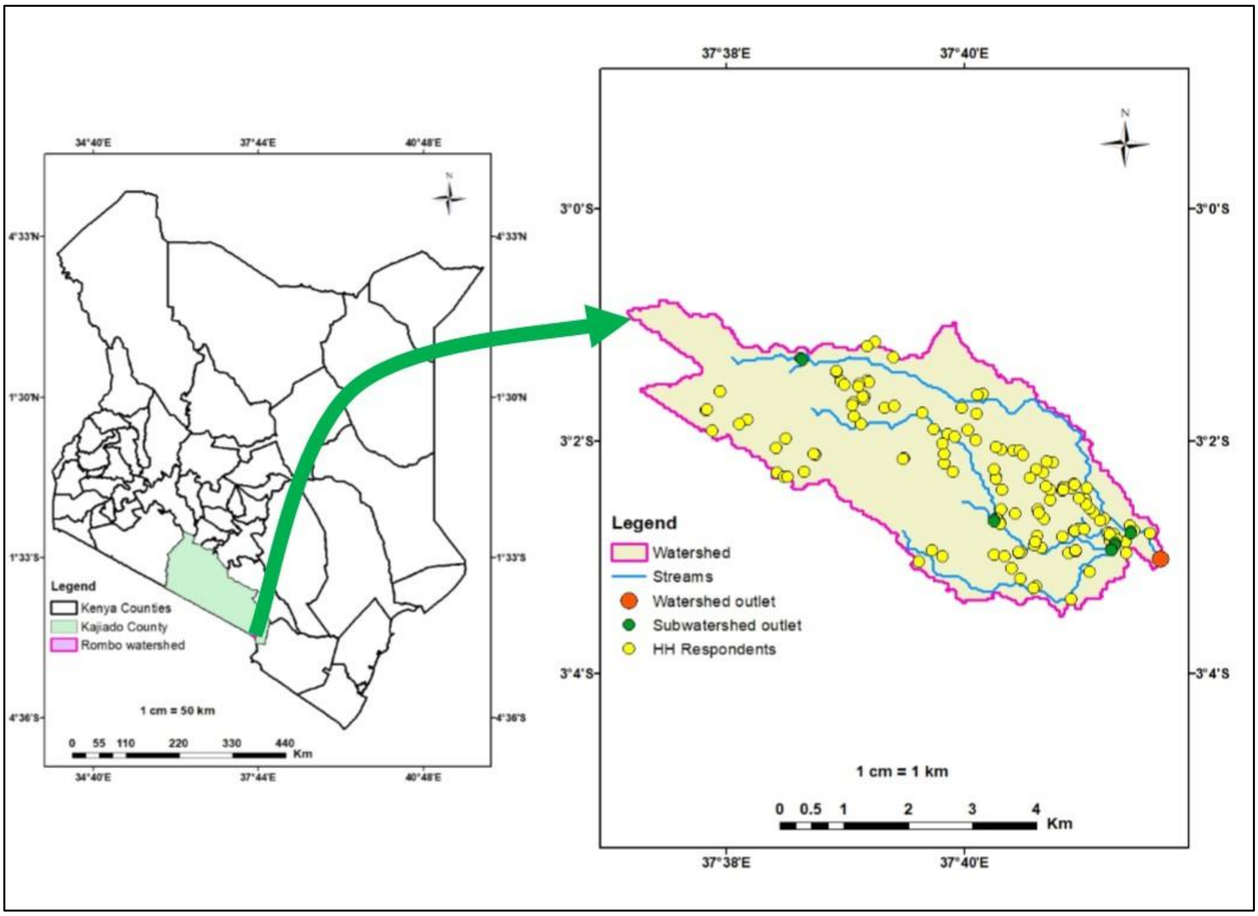

Figure 1. The relative location of the sampled farmers in Rombo watershed of Kajiado county

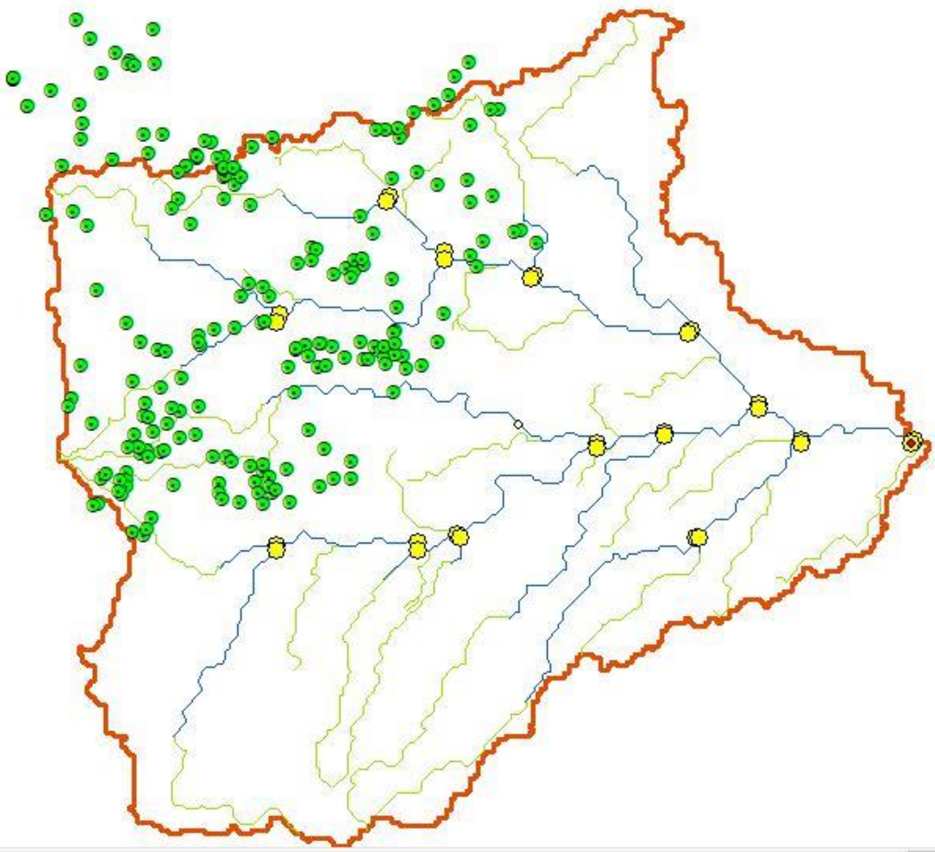

Figure 2. Mondabogho watershed in Taita Taveta County with relative location of sampled farmers

1.3 ON-SITE SOIL EROSION IN ROMBO AND MWONDABOGO WATERSHEDS

The soil detachment, transportation and deposition caused mainly by water, wind and gravity that take place within the agricultural fields where actual farming takes place is referred to as on-site soil erosion. On-site soil erosion may have one or a number of composite adverse effects such as reduction in soil quality, removal of organic matter, minerals and other plant nutrients, reduced soil water-holding capacity, reduced cation exchange capacity, reduced biological activity, spread of plant disease organisms, reduced water infiltration into the soil, increased direct water runoff, exposure of plant root systems and uprooting of vegetation, fruit and foliage damage. Others include formation of gullies that make farm operation and use of machinery difficult and water pollution as runoff water transport eroded materials along the agricultural fields (refff xx). The on-site soil erosion may be accelerated by poor land management. Some of the common types of erosion are;

Sheet erosion: in sheet erosion, top soil is usually eroded in layers leading to loss of soil fertility on the surface of land and thus low land productivity.

Rill and inter-rill erosion: Rill erosion refers to the detachment of soil particles on land forming shallow channels that can be removed by normal tillage operations. On the other hand inter-rill erosion is the detachment of particles from the areas that lie between the rills.

Splash: Raindrops have kinetic energy whose impact on the surface of the soil is sudden detachment of soil particles in all directions leading. The splash is rampant on bare soil surfaces.

Gully erosion**:** gully erosion may be influenced by the interaction between the soil characteristics, channels, side walls, nature of land including slopes and the seasonal precipitation parameters such as duration, distribution, quantity average and maximum intensity (Luffman and Nandi, 2020)

Some of the erosion sites within the watershed for specific erosion types are captured and presented in Figures 3 to 5.

Figure 3: Sheet and rill erosion at Rombo watershed (Photo by Raphael M. Wambua)

Figure 4: Gully erosion at the Rombo watershed (Photo by Raphael M. Wambua)

Figure 5: Exposed pant root system due to soil erosion(Photo by Raphael M. Wambua)

STATE OF SOIL EROSION ACROSS ROMBO WARER SHADE

A field survey conducted using a questionnaire show that farmers in Rombo are aware of the soil erosion taking place in their farms. However, they have not yet been able to quantify the extent of soil erosion neither do they practice effective soil and water conservation on their farms. The following graph shows the state of soil erosion across the four villages covering Rombo watershed (Figure 6), categorized into three levels mild, moderate and severe soil erosion.

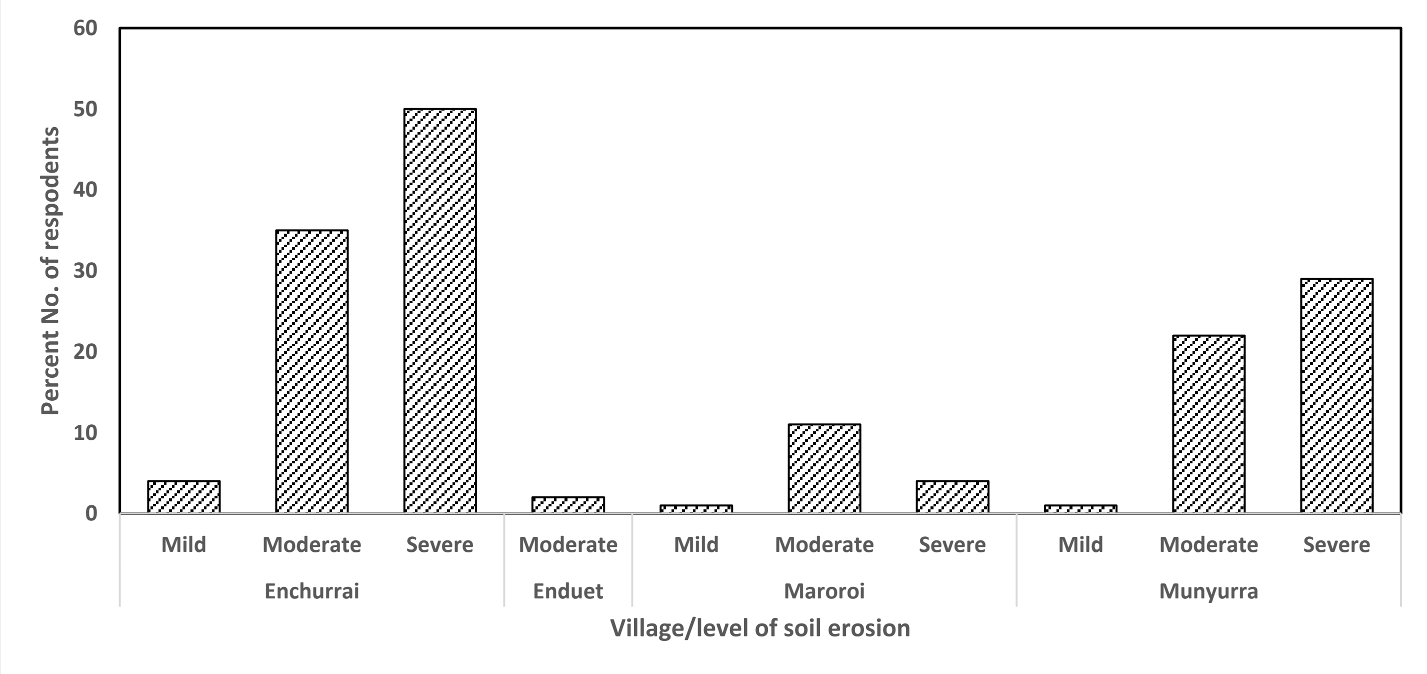

Figure 6. The level of soil erosion within the villages in Rombo watershed

- 50, 35 , 5 percent of the respodents indicated that Enchurrai village experience –severe, moderate and mild soil erosion respectively
- 10, 4 and 2% of the respondents in Enduet village indicated that the area experience severe drought, modeate and mild soil erosion respectively
- 30, 25 and 2 percent of the respondents in Munyurra village experience severe, moderate and mild soil erosion respectively

The results show that Enchurrai village is the most affected in Rombo watershed by soil erosion followed by Munyurra, Maroroi and Enduet villages in that order. This ranking is key for prioritized soil and water conservation since it shows that any strategies to conserve soil and water on agricultural fields should be begin by Enchurrai village followed by the others in the same order.

SOIL TYPES

Based on the questionnaire administered in Rombo watershed farming community, and physical field observation, the soil types were assessed as these affect the rate of soil erosion. The following diagram (Figure 7) shows the type of the soil across different villages in Rombo Catchment

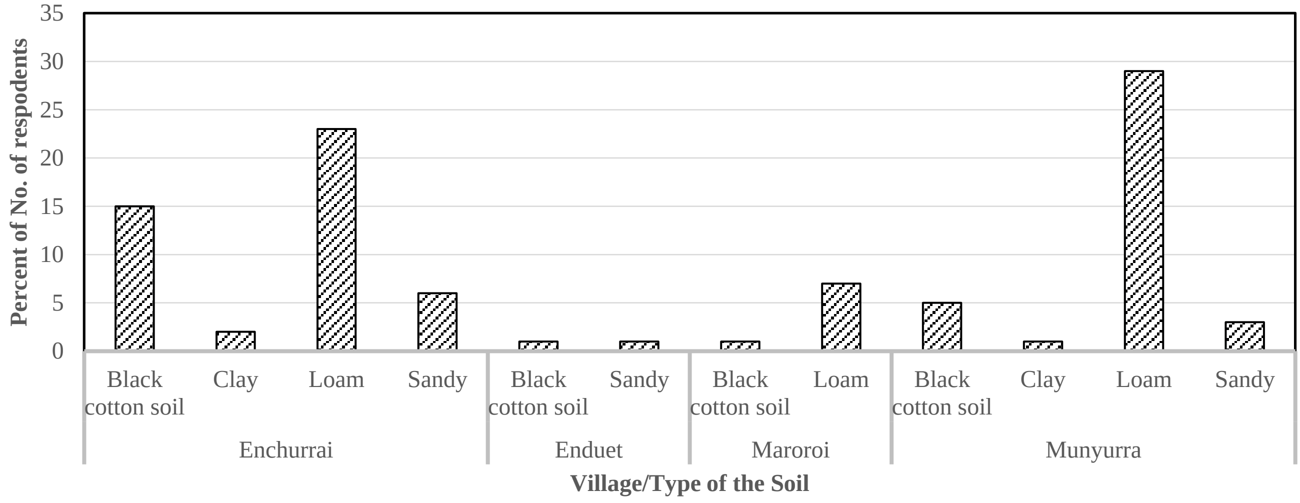

Figure 7. Distribution of soil types across the villages in the Rombo watershed

From the above data 15, 3, 23 and 6 percent of the respondents indicated that their soil is black cotton, clay, loam and sandy soils respectively. It was also observed that 2 percent of the respondents in Enduet village showed that the soil is both black cotton and Sandy soils. Additionally, 2, 7 percent of respondents in Maroroi Village indicated black cotton and loam soils respectively. 5, 2, 28, and 3 percent of respondents in Munyurra indicated black cotton, clay, loam and sandy soils respectively.

It was found that the dominant soil type for Enchurrai, Maroroi and Munyurra villages was Loam soils. The other soils occurring within these three villages are black cotton, clay and sandy in different proportions. Enduet village had two main types of soil; black cotton and sandy soils almost equally distributed. The soil types influence the soil erodibility factor. For instance the soil erodibilty factor K values for sand, loam and clay soils may range from 0.05 to 0.2, 0.025 to 0.4 and 0.05 to 0.15 based on English units.

DIFFERENT LAND TERRAIN IN ROMBO WATERSHED

Different number of farmers had their agricultural land terrain categorized into steep, gentle and flat. This was for the purpose getting preliminary data on possible soil and water conservation structures that can be designed and installed in the fields. In addition, this data is important for the purpose of identifying the optimum options for labour needed in layout of soil and water conservation structures (Figure 8).

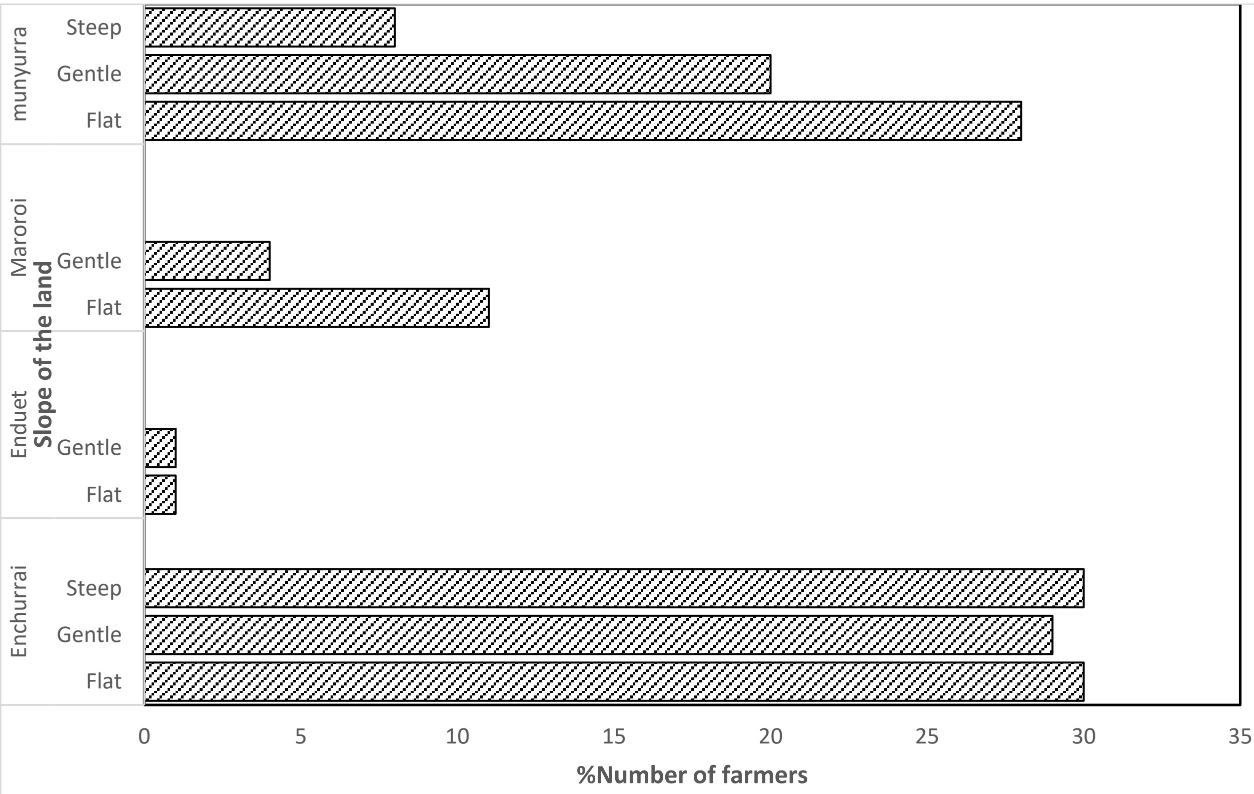

Figure 8. Variation of land terrain across villages in Rombo watershed

Out of the sampled households, Enchurrai village had higher number of farmer-respondents whose agricultural land exhibited steep, gentle slopes, followed by Munyurra, Maroroi and Enduet in that order. This is information is key for prioritized layout of the SWC structures.

REVIEW OF MAIN CROPS AFFECTED BY SOIL AND WATER CONSERVATION

The graph below shows that Soil erosion affects crop yields due to plant nutrient loss and reduced water infiltration and holding capacity. A baseline survey was conducted to find out the crop yield for commonly grown crops in Rombo watersheds. The crop yields based on data from the farmers in the year 2020 was estimated. A year with “normal” growing conditions for low levels of inputs at smallholder farmer level was considered. There were many variations, including seasonal growing conditions, local soil type, farmer skills, seed quality and many other factors that affect the actual yields across the County. The data was plotted to get yield for each of the common crops grown in Rombo (Figure 9).

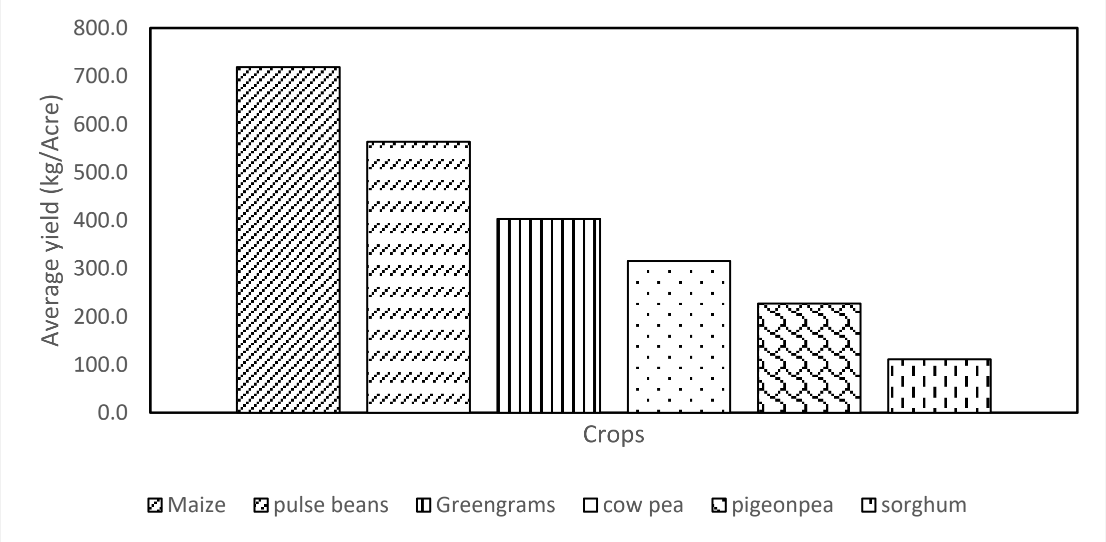

Figure 9. Average grain yield for common crops grown in Rombo watershed

The results indicate that the average yield for the study area was 719, 563, 404, 316, 227 and 111 kg/acre for maize, pulse beans, green grams, cow pea, pigeon pea and sorghum respectively. This is quite low compared to optimum expected yields for these respective crops in ASALs. The low production is attributed to on-site soil erosion among farm factors that are shown in Figure 10.

1.5 Variables that affect SWC practices at farm level

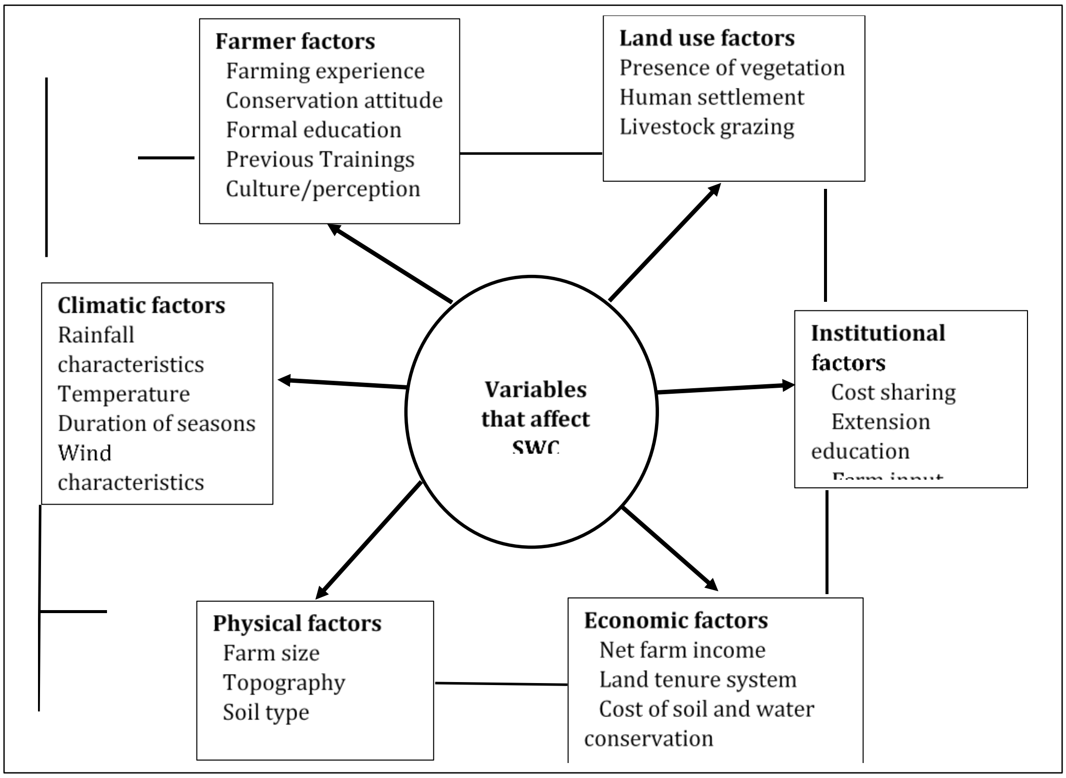

Figure 10. Variables that affect SWC practices in farms located in Rombo and Mondabogho watersheds

1.6 SWC PRACTICES SUITABLE FOR THE WATERSHEDS

Mechanical measures have greatly been used to effectively conserve soil and water on agricultural fields in numerous parts of the world (Ahuchaogu *et al*., 2022; Huang *et al*., 2022). Mechanical also referred to as engineering structures that are designed and installed on land to modify the land, convey runoff water away at low velocity, reduce sedimentation and improve water quality. These structures may work in isolation or can be integrated with biological structures to enhance their efficiency, make them sustainable and reduce maintenance cost (Huang *et al.*, 2022). The mechanical measure may be constructed using manual or mechanical methods. A number of mechanical soil erosion control structures are in use, these include:

Terracing**:** Terraces are earth embankments constructed across the dominant slope to partition the field into sections. The terraces may have channels that capture, retain and convey runoff to the designated outlets at reduced velocity. These structures reduce the degree and length of slope thus reducing runoff velocity, soil erosion and increases infiltration. a number of terraces that are in use including bench terrace sling inward, bench terrace sloping outward, intermittent bench terrace, bench terrace with level top (Ahuchaogu *et al*., 2022).

Contour bunds: Contour bunding: it is used to conserve soil moisture and reduce soil erosion on land with slopes of 2-6% and mean annual precipitation of less than 600 mm for permissible soils. The vertical interval between two consecutive bunds is called bund spacing, which is dependent on erosive velocity of runoff, slope steepness, slope length, rainfall characteristics including intensity, type of crops and conservation practices.

- Graded contour bunding: these are constructed with a mild slope on the bunds. They are used for conveying away the excess runoff water safely in areas with 6-10% land slope, annual average rainfall of more than 750 mm and soil infiltration capacity of less than 8 mm/hr.
- Peripheral contour bunds:

Contour trenching: These are channels constructed at the contour line to reduce runoff velocity, capture and increase retention time for runoff water in the soil. This lead to increased infiltration within the soil mass. Contour trenching is used in areas with slopes that are greater than 30%. Two contour trenches may be adopted; continuous contour trench and staggered contour trench. The former is constructed in areas with low rainfall at 10-20 cm trench length and may be continuous in a trench length of 10-20 m. The latter are laid in alternate rows in a staggered manner in high rainfall areas. These may be 2-3 m long with 3-5 m spacing between rows.

Biological measures of soil and water conservation may be employed where vegetative materials are applied. Other specific techniques of SWC include Contour farming, Crop rotation, Conservation tillage, Cover crops, Intercropping, Strip cropping, Mulching, Organic farming and Agroforestry.

1.7 CONCLUSION AND RECOMMENDATIONS

1.7.1 CONCLUSION

Food and nutritional security in Kajiado and Taita Taveta counties has been low due to overdependence on rainfed agriculture. Crop production has subsequently been affected by the climate change due to land and water resources degradation. The type of soils differed in the watershed, ranging from sand, black cotton, loam and clay which affected rate of soil erosion. The terrain of the farmers' lands also differed with steep and gentle slopes observed and this affect erodibility. Such information are key in prioritizing SWC structures layout and useful in formulating sustainable interventions for soil and water conservation for increased land productivity.

Farmers were also aware of factors that determine SWC practices, ranging from farmer characteristics, land use, climatic, institutional, physical and economic. These factors are critical in considering adoption of SWC structures and its sustainability. It was found that these watersheds do not have adequate SWC structures and that the few that are in existence have been constructed manually.

1.7.2 RECOMMENDATIONS

a) The study explores and recommends a sustainable mechanized soil and water conservation in the two watersheds whose benefits include:

(i) Achieving food and nutrition security

(ii) Increase land productivity whereby the farm operations are done within desirable timelines and quality of work

(iii) Mitigation of farm labour shortage in commercial farms

(iv) Improves peoples livelihoods and well-being vie reduction of drudgery

(v) Establishment of SWC structures that mitigate climate change effect

b) Highlight and recommend alternative ways of addressing SWC to meet the needs of farmers within the two watersheds:

(i) Manual soil and water conservation

(ii) Biological methods of SWC

(iii) Cultural SWC techniques

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