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Evaluation of Household Soil Conservation Technologies in Arid and Semi-Arid Lands (ASALs) (The Case of Kitui Central, Mulala and Wote Divisions in Kenya)

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MKK, TIK and WR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author MRM managed the literature searches, final analysis and final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study aimed at establishing the status of soil conservation technologies in arid and semi-arid lands (ASALs) in Kitui Central, Mulala and Wote divisions in Kenya. The survey was carried out between July and August 2010. To allow for comparison, purposive sampling that considered diversity in terms of agro-ecological setting, population trends and infrastructural facilities was done to select the locations for the study in the three divisions. Simple random sampling was used to select 503 households from six locations in the three divisions for interview. Questionnaires, Focus

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Group Discussions (FGD) and field observations were used to collect qualitative data. Results indicate main soil types as sandy (31.7%), loam (50.1%) and clay (18.2%). Soil fertility maintenance was by adding organic manure (51%) and inorganic fertilizers (22.8%). Main conservation structures of soil in crop fields included terraces (53.9%), planted trees (28%) and planted nappier grass (7.8%) while main agricultural water sources were public tap, stream and pond dam water. Soil conservation was done by less than 50% of households despite the importance towards crop growth, yield and ultimately food security.

Keywords: Soil conservation; ASALs; soil type; soil fertility; water source.

1. INTRODUCTION

Soil and water conservation is a common term used in agriculture. Soil conservation refers to the preservation of soil against degradation or erosion and the maintenance of elements and nutrients for crop production [1]. Soil and water conservation in Kenya began in 1930s. During those times the colonial government forced local people to work in conservation projects including terraces and ditches [2] without explicitly giving information on the benefits of the conservation. Thus communities developed the notion of forced labour as part of colonization. This led to low attention by communities and Kenyan government after independence. Most of the terraces were then destroyed. At the same time more steep land was opened up for cultivation and settlement as the population expanded. Due to the associated problems of land and water resources degradation, the Government of Kenya sought international assistance from the United Nations (UN) in 1972 at Stockholm, Sweden where the National Soil and Water Conservation Programme was introduced to curb down desertification [3].

Water is the most limiting factor for agricultural production especially in dry lands where low annual rainfall is often a major reason for food insecurity. The rains in dry areas are usually erratic and characterized with high intensity leading to loss through intense surface runoff. Increasing water retention of soil in dry lands would in turn lead to increased crop yield. The most appropriate way to increase water availability to crops would be irrigation but it is usually not the best option in ASALs due to limited water sources. Another main method is terracing but it requires high labour costs. Water harvesting can make use of surface runoff through collection of the runoff for productive purposes, while soil moisture retention aims at preventing runoff and keeping water as much as possible in the place where it falls [4]. Soil conservation techniques commonly used include use of inorganic fertilizers, organic fertilizers [5], afforestation, planting ground cover crops, contour ploughing, zero tillage, establishing wind breaks, mixed planting, conservation of wetlands among others [6]. Therefore, water management is important in soil conservation. Within dry land environment, soil erosion is rampant especially on steep slopes where there is accelerated erosion hence causing land degradation [7].

The main objectives of this study were to highlight; household demographics, soil types, soil conservation measures, existing structures for water and soil conservation and sources of water for agricultural use. This study is further justified by the focus of modern science and farming on attaining food security which in return is dependent on the extent of water and soil resources management [8].

2. METHODOLOGY

2.1 The Study Areas

The study was conducted in Kitui Central division in former Kitui District, Mulala and Wote divisions in former Makueni District. The divisions are located in the arid and semi arid zones in South Eastern Kenya (Fig. 1). The divisions experience two rainy seasons namely; the long rains from March-April and short rains from November-December. The rest of the year is warm and dry.

The settlement patterns are greatly influenced by climate and water availability, the most densely populated division was Kitui Central with 153 persons per square Kilometer [9].

2.2 Data Collection and Analysis

The survey adopted a case-study approach, whereby personal judgment was relied upon in deciding which members of the population to include in the sample. The population comprised of all the administrative locations in Kitui Central,

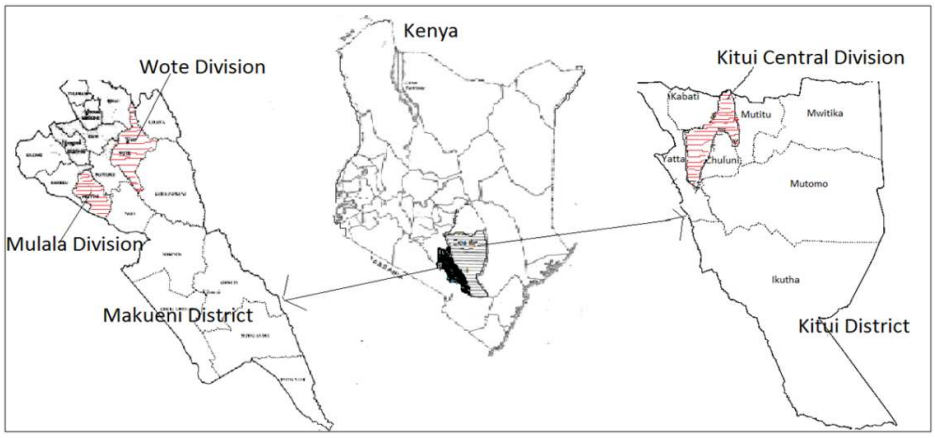

Fig. 1. Map of Kenya showing location of Wote, Mulala and Kitui central divisions

Mulala and Wote divisions. Purposive sampling procedure was used to sample 6 administrative locations based on their diversity in terms of agro-ecological setting, population trends, and infrastructural facilities. This enabled a comparative analysis of the study area(s). Random sampling procedure was employed to select and interview at least 100 households from each of the 6 identified locations. In Kitui Central Division four locations out of eight were sampled, in Mulala Division one location out of four was sampled while in Wote Division out of three locations, only one was sampled.

A total of 503 out of the anticipated 600 households were interviewed. Out of these 109, 264 and 130 were interviewed in Kitui Central, Mulala and Wote divisions respectively. Data for this study was derived from primary sources which included (a) Observation by the researchers recorded by use of a field notebook. (b) Focused Group Discussion (FGDs) drawn to represent women, youth and men from different sub-locations with the help of local leaders. (c) Questionnaires. A pilot survey was undertaken to pre-test the questionnaire for clarity, validity and reliability with regards to the following aspects of a household; social economic characteristics and soil conservation. The questionnaire was further revised on the basis of pilot survey. The raw data was cleaned, coded and entered into MS Excel spreadsheet for analysis.

3. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Households

The average household size was 4 persons. About 15% of households were headed by persons aged above 61 years, 48% by persons aged between 41 and 60 years, 36% by persons aged between 21 and 40 years and 1% by persons below 20 years of age. In all the three divisions, majority (39%) had attended school up to primary level. About 71% of households were female headed. Majority (66.6%) of houses were permanent with Wote division having the highest proportion. On average, iron sheets (70%) and plastered cement (54%) were the most common roofing material and floor type respectively (Table 1).

Studies by [10] within Kitui County indicates average household sizes of above 5 persons while in Makueni County, [11] indicate average household sizes of 6 persons. Household size is important as a source of family labour towards soil conservation. Women make up two-thirds of the agricultural labour force and produce the majority of Africa's food [12]; this therefore places them as key agents in soil conservation measures. With high education levels, farmers' intellectual capacity is expected to be high [13]. This would in return enhance application of proper soil conservation practices.

Housing characteristics is an indicator of levels of income/wealth [14]; with permanent houses depicting higher incomes while grass thatched houses depicting poverty. About 66.6% and 19.7% of houses were built using permanent materials and mud respectively. The main material used to construct permanent houses were bricks made from soil stabilized with little cement while mud houses were constructed by plastering mud on walls. During sourcing of the soil, ditches were dug hence affecting soil conservation efforts.

3.2 Soil Types

The averages for soil types in the study areas were; loam soil (50.1%), sandy soil (31.7%) and clay soil (18.2%) (Table 2). The common soil type in the divisions was sandy loam.

[6] Also indicates sandy loam as the main soil type in Kitui County. Soil type is among the factors that influence zonation in Kenya [15] or indicate whether an area is suited for agricultural activities [16].

3.3 Soil Conservation

Conservation of soil in the three divisions was mainly maintained by adding organic manure (51%) and inorganic fertilizers (22.8%). Other methods were terracing (10%), crop rotation (9.4%) and intercropping (4.3%). Kitui Central had minimal soil conservation (Table 3).

Table 1. Socio-economic characteristics of the selected households

Variables	Study sites (divisions)			Study area
Characteristics	**Kitui central**	**Mulala**	**Wote**	**Average**
Average household size	4.7	4.3	5.1	4.6
Average age of household Head	45.5	47.3	48.6	47.2
Education of household head (%)				
Adult	10.1	14.4	8.5	11.9
None	3.7	1.9	1.5	2.2
Primary	45.0	39.0	35.4	39.4
Secondary	26.6	22.7	29.2	25.2
Tertiary	12.8	12.9	21.5	15.1
No response	1.8	9.1	3.8	6.2
Total	***100.0***	***100.0***	***100.0***	***100.0***
Gender of household head (%)				
Male	53.2	23.1	20.0	28.8
Female	46.8	76.9	80.0	71.2
Total	***100.0***	***100.0***	***100.0***	***100.0***
Housing Characteristics (%)				
House type				
Permanent	55.0	62.5	84.6	66.6
Mud	33.9	16.7	13.8	19.7
Wooden	0.9	0.0	1.5	0.6
No response	10.1	20.8	0.0	13.1
Total	***100.0***	***100.0***	***100.0***	***100.0***
Roof type				
Tile	0.0	1.5	2.3	1.4
Iron sheet	65.1	61.7	89.2	69.6
Thatch	24.8	17.8	8.5	16.9
No response	10.1	18.9	0.0	12.1
Total	***100.0***	***100.0***	***100.0***	***100.0***
Floor type				
Mud	45.0	35.2	20.8	33.6
Plastered cement	44.0	44.7	79.2	53.5
No response	11.0	20.1	0.0	12.9
Total	***100.0***	***100.0***	***100.0***	***100.0***

Table 2. Percent (%) of soil types found in Kitui Central, Mulala and Wote divisions

Soil type	Kitui central division	Mulala division	Wote division	Average
Sandy	28.8	42	24.2	31.7
Loam	60.4	43.2	46.8	50.1
Clay	10.8	14.8	29	18.2

Table 3. Percentages (%) use of soil conservation options in the three divisions

Variable	Kitui central division	Wote division	Mulala division	Average
Terracing	1.2	9.8	19.1	10
Crop rotation	8.1	4.8	15.2	9.4
Fallowing	1	1	0.9	1
Inter cropping	8.7	1	3.1	4.3
Mulching	1	0.9	1.1	1
Organic manure	52.1	52	49	51
Tree planting	1	1	4	2
Fertilizer application	23.4	28.6	16.4	22.8

[5] Agrees that few farmers in south eastern livelihood zones of Kenya use inorganic fertilizers since they argue that inorganic fertilizers damage the soils, while others claim that the soils are fertile enough and do not need fertilizers. Use of organic manure was common since most households have livestock hence an opportunity for improving soil structure, nutrients and water holding capacity. The level of soil management is important since it can affect crop yield. Soil management can also influence spatial variability in crop yields within farms [17]. [18] Indicates that Kenyan farmers in general are improving soil conservation by use of both inorganic and organic nutrient sources such as manures, composts and traditional fallows.

3.4 Soil and Water Conservation Structures

A number of soil conservation structures were found in the study sites. The average use for the three study sites were; terraces (53.9%), planted trees (28%), planted nappier grass (7.8%) and constructed gabions (6.8%) (Fig. 2). Most of these structures required intensive labour to construct.

Bench terraces are used world over and are effective for soil conservation on slope lands [19]. The soil conservation structures listed in Fig. 2 mainly serve to reduce surface runoff. When runoff is trapped and encouraged to infiltrate, soil moisture availability increases and crops can thereby withstand dry spells and droughts better leading to higher yields. Also, there is higher seedling survival rate [4]. [11] indicates similar findings in Makueni County where most of water harvesting techniques were labour intensive and recommends research on appropriate technologies to lessen the labour needs and address gender issues.

3.5 Sources of Water for Agricultural Use

On average, main water sources in the study area were; public tap water (44.8%), stream water (27.4%) and pond dam water (11.4%). The main source of water in Kitui central and Mulala divisions was public tap water while in

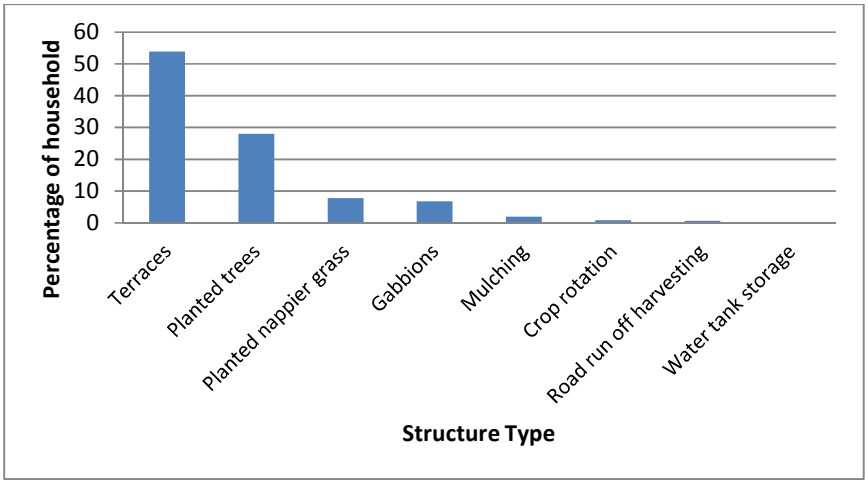

Fig. 2. Soil and water conservation structures in the study area

Table 4. Domestic and agricultural sources of water for the households (%)

Water sources	Kitui central division	Mulala division	Wote division	Average
Public well water	4	11.5	4.3	6.6
Yard/plot shallow well	8	2	3.3	4.4
Piped yard/plot water	1	0	8.7	3.2
Pond dam water	14	7.1	13	11.4
Public tap water	56	55.2	23.2	44.8
Stream water	17	21.8	43.5	27.4
Protected well water	0	0	1.4	0.5
Rain water	0	0	1.4	0.5

Wote it was stream water. Direct use of rain water was rare in all the three divisions since the areas receive few amounts of rainfall and over short periods (above Table 4).

From the Focus Group Discussions, it was reported that about 1% of households in Wote practiced irrigated small scale agriculture. In Kitui Central and Mulala field observations revealed that irrigation was practiced along the river banks and in the vicinity of shallow wells.

To supplement existing water sources, [20] recommends sinking of boreholes for domestic water and irrigation development. For ground water storage, several ways are suggested; sand dams, subsurface dams, controlling sand and gravel mining, infiltration ponds, trenches/ditches and wetland protection. For open reservoir storage; in stream storage, small storage reservoirs, off stream storage, road water harvesting and hillside storage are recommended. The Africa Water Vision for 2025 visualizes an Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socioeconomic development, regional cooperation and the environment [21].

4. CONCLUSION AND RECOMMENDATIONS

The main soil type in the study area was sandy-loam. Soil conservation was mainly increased through use of organic manure and inorganic fertilizers. Main soil and water conservation structures in the crop fields were; terraces, constructed gabions, planted trees and nappier grass. Main agricultural water sources were public tap, stream and pond dam water.

For purposes of improving food security in ASALs, farmers should be trained on proper design, layout and utilization of soil conservation structures. Also, farmers should be sensitized on adoption of efficient water use technologies at farm level, conservation tillage, and construction of large community-based earth dams to harvest runoff hence increase water availability.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sanders D. Soil conservation. World association of soil and water conservation, Bristol, England, UK. 2011;4.
   Available:http://www.eolss.net/Eolss-sampleAllChapter.aspx
   (Accessed 11th March 2016)
2. Tiffen M, Mortimore M, Gichuki F. More people, less erosion – Environmental recovery in Kenya. ACTSPRESS, African Centre for Technology Studies, Nairobi, Kenya. 1994;301.
3. Dregne HE. Desertificaion of of arid lands in physics of desertificaton, ed. El-Baz F, Hassan MHA. Dordrecht, The Netherlands: Martinus, Nijhoff; 1986.
4. The farm Level Applied Research Methods for east and Southern Africa (FARMESA) soil and water conservation with a focus on

water harvesting and soil moisture retention. 2003;Version 1.1.

5. FAO. Seed Security Assessment in the South-Eastern livelihood zones of Kenya. Food and Agriculture Organization of the United Nations. Rome; 2014.
6. Winfred KW. A study of erosional features and environmental restoration of river Kalikuvu catchment in Kitui County, Kenya. MSC Theses, Department of Geography & Environmental Studies, University of Nairobi; 2014.
7. Tong STY, Chen W. Modeling the relationship between land use and surface water quality. Journal of Environmental Management. 2002;66(4):377-393.
8. Delgado JA, Groffman PM, Nearing MA, Goddard T, Reicosky D, Lal R, et al. Conservation practices to mitigate and adapt to climate change. Journal of Soil and Water Conservation. 2011;66(4):118-129.
9. Government of Kenya. Food Security District Profile, Kitui District, Eastern Province; 2008.
   Available:http://kitise.org/attachments/article/1/kitui_food_security_profile.pdf
   (Accessed 19th March 2016)
10. Mwobobia RM. Challenges facing poultry farmers in Katulani district, Kitui County. MSC Theses, Department of Range and Wildlife Sciences, South Eastern Kenya University; 2016.
11. Kimani MW, Gitau AN, Ndunge D. Rainwater harvesting technologies in Makueni County Kenya. International Journal of Engineering and Science. 2015;5(2):39-49.
12. ADB. Empowering African women, an agenda for action; Africa gender equality index; 2015.
    Available:http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/African_Gender_Equality_Index_2015-EN.pdf
    (Accessed 3rd May 2016)
13. Kyule NM, Nkurumwa OA, Konyango JJO. Performance and constraints of indigenous chicken rearing among small scale farmers in Mau-Narok ward, Njoro sub county, Nakuru County, Kenya. International Journal of Advanced Research. 2014;3(3): 283-289.
    Available:http://www.journalijar.com/uploads/74_IJAR-5175.pdf
14. Amendah DD, Buigut S, Mohamed S. Coping strategies among urban poor: Evidence from Nairobi, Kenya. 2014.9(1): e83428.
    DOI: 10.1371/journal.pone.0083428
15. Otolo JRA, Wakhungu JW. Factors influencing livelihood zonation in Kenya. International Journal of Education and Research. 2013;1(12).
16. Soil Atlas of Africa Pp47.
    Available:Http://Eusoils.Jrc.Ec.Europa.Eu/Library/Maps/Africa_Atlas/Download/47.Pdf
    (Accessed 28th March 2016)
17. Tittonell P, Shepherd KD, Vanlauwe B, Giller KE. Agriculture, ecosystems and environment. 2008;123:137–150.
    DOI: 10.1016/j.agee.2007.05.005
18. Gicheru P. An overview of soil fertility management, maintenance and productivity in Kenya; 2012.
    DOI: 10.1080/03650340.2012.693599
19. Ted C Sheng. Bench Terrace Design Made Simple 12th ISCO Conference Beijing; 2002.
    Available:https://www.scribd.com/doc/90744097/Bench-Terrace-Design-Made-Simple
    (Accessed 3rd May 2016)
20. Sobona M, Alan N. Good practices in water development for drylands. Soil Atlas of Africa. 2013;47.
    Available:http://eusoils.jrc.ec.europa.eu/library/maps/Africa_Atlas/download/47.pdf
    (Accessed 28th March 2016)
21. Mati BM, Muchiri JM, Njenga K. Penning de Vries F, Merrey DJ. Assessing water availability under pastoral livestock systems in drought-prone Isiolo District, Kenya. Working Paper 106. Colombo, Sri Lanka: International Water Management Institute (IWMI); 2005.

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