EFFECT OF SOIL DEGRADATION ON HOUSEHOLDS' FOOD SECURITY IN RACHUONYO NORTH SUB-COUNTY, HOMA-BAY COUNTY, KENYA

BY

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DECLARATION

Declaration by the candidate

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DEDICATION

I dedicate this Thesis to my beloved dad, Peter Akomo Ojala and my loving mum, Jecinta Auma Akomo. This fulfills my heart.

ABSTRACT

Though food security is a consequence of multiple factors including biodiversity integrity, water security, and human health conditions, soil quality plays an important function in determining the level of food production. Measures such as irrigation, green house technologies, and pest-disease control mechanisms have been used both as long and short term measures to overcome the effects of the aforementioned factors on crop yield. These efforts are more fruitful if soil health is maintained. However, the extent of soil degradation in the area and its effect particularly on food security remain unresolved. Therefore, this study aimed at assessing the effect of soil degradation on food security among the households of Rachuonyo North Sub-County, Homa-Bay County in Kenya. Specifically, it examined the common anthropogenic practices causing soil degradation, established the nexus between soil degradation and food security situation among the households in the area of study, and investigated common soil conservation and management strategies in the area. The Misesian theory of Praxeology was used in this study in which human endeavour (practice or action) based on the desire to fulfil the current existing economic needs such as food, considerably results to soil degradation which consequently limits agricultural opportunities hence causing food insecurity. This consequently provides learning opportunity to human being to re-direct energy towards adopting appropriate soil health management practices. While the study population was approximately 32,500 households, Cochran formula was used to obtain sample size of 289 respondents who were identified using multi-stage together with simple random sampling techniques for quantitative data in addition to 5 Key Informants, who were purposively identified for qualitative data. The study was based on cross-sectional survey study design. The data analyses involved both descriptive and inferential statistics. The data were subjected to significant test using Binary Logistic Regression Data Analyses (BLRDA) at 95% CL. Qualitative analyses were based on opinions drawn from FGDs, KII, Direct Field Observation and questionnaire. Data presentation involved graphs display, charts and drawing tables. The study findings revealed that majority of the respondents indicated that soil degradation is common as a consequence of anthropogenic practices. Among the investigated practices, the findings of BLRDA revealed that stone mining (OR = 2.130, 95% Cl; $p < 0.05$), conventional-tractor tillage (OR = 2.613, 95% Cl; $p < 0.05$), together with hill slope cultivation and settlement (OR = 2.227, 95% Cl; $p < 0.05$) were statistically significant hence accurately predicted food insecurity in the area. The study concludes that these anthropogenic practices are the major cause of soil degradation resulting to reduction in food crop production thus consequently imposing food insecurity threats among the HHs in the study area. The study therefore, recommends suspension of human activities on the steep slopes in the area particularly Homa-Hills, controlling stone extraction, re-viewing the use of tractor farming, and intensive afforestation and reforestation as measures against soil degradation. For further research, the study suggests a study on effect of land degradation on human settlement among the households of Homa-Bay County in Kenya.

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ACRONYMS AND ABBREVIATIONS

ASALs	Arid and Semi-Arid Lands
AWC	Available Water Capacity
BLRDA	Binary Logistic Regression Data Analysis
CPA	Community Participation Approach
EU	European Union
FAO	Food and Agriculture Organization of the United Nation
FBO	Field Based Observation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIS	Geographic Information Systems
HHs	Households
HWSD	Harmonized World Soil Database
IDP	Integrated Development Plan
IFPRI	International Food Policy Research Institute
IOP	Institute of Physics Publication
ISFM	Integrated Soil Fertility Management
ISRIC	International Soil Reference and Information Centre
ITPS	Intergovernmental Technical Panel on Soils
KALRO	Kenya Agricultural and Livestock Research Oganisation
KFSSG	Kenya Food Security Steering Group

KII	Key Informant Interviews
KIHBS	Kenya Integrated Household Bureau Survey
KNBS	Kenya National Bureau of Statistics
LADA	Land Degradation and Assessment
MAL&F	Ministry of Agriculture, Livestock and Fisheries
NACOSTI	National Commission for Science, Technology and Innovation
NEMA	National Environment Management Authority
NRCS	National Resource Conservation Services
pH	Hydrogen Potential
RS	Remote Sensing
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
UNCCD	United Nations Conservation to Combat Desertification
UNGA	United Nations General Assembly
WAO	Ward Agricultural Officer
WHC	Water Holding Capacity
WHO	World Health Organization

DEFINITION OF OPERATIONAL TERMS

Anthropogenic practices	Intensive Human-Based agricultural and non-agricultural decisions taken by households to improve their livelihoods while have both short and long term negative effect on soil quality hence likely to cause food insecurity.
Conservation and management	Any biophysical measures taken by the area residents to stop or reduce soil degradation in the farms.
Conventional tillage	Inappropriate tractor tillage which leads to disruption of soil physical properties including reduction in crop residue hence making it more vulnerable to action of water and wind which ultimately decreases its productive quality.
Effect	Negative results of anthropogenic soil degradation practices on food security in the area
Food security	Adequate supply of stable foods such as maize and sorghum in a manner that satisfy the needs of the area residents.
Hunger	High household level of uncomfortable situation leading to increased desire for food.
Marginal land	These are lands in the area of study whose top soils have been removed due to mining and sand harvesting hence have limited agricultural value thus their potential to produce sustainable crop yield is greatly reduced.

Restricted farms	These are less potential agricultural farms due to formation of multiple gullies in the farms as well as depletion of nutrient as occasioned by rapid surface run offs and unsustainable agricultural practices such as monoculture hence reduction in the overall crop yield.
Soil degradation	Soils in the study area with deep surface cuts as well as no or reduced nutrient content such that they are not agriculturally viable.
Soil management	Any anthropogenic-based initiatives aimed at improving and maintaining soil nutrients and other essential bio-physical components in a manner that is increasing its productivity
Soil quality	Soils with adequate nutritional content and proper physical properties hence agriculturally viable.
Starvation	The household-based sufferings including but not limited to stress, domestic conflict, and low living standards due to inadequate or low supply of food resources

CHAPTER ONE

INTRODUCTION

1.1 Background Information

In relation to its composition, Natural Resource Conservation Service (2008) defines soil as a natural resource comprising of air, moisture, minerals as well as organic matter that occur in and on the land surface. The importance of the soil according to Brevik *et al* (2009) is primarily relating to its function of providing nutritional contents as well as anchorage for the vegetation and these help in ensuring adequate vegetation cover in an area. Yet still, it is this soil that studies of (Ye *et al* 2009, & Xie, 2020) opine that its degradation is almost two billion hectares of the total soil resources in the world, and this represents about 22% of the agricultural lands, grazing zones, forest and other essential vegetation. On soil formation, Pimentel & Burgess (2013) observed that the process of soil formation is between 10 to 40 times slower compared to the rate of its loss. This implies that its replenishment is close to impossible if the rate of its removal is not contained. Additionally, this problem may go all the way to affecting human races whose livelihoods largely rely on soil productivity (Bindraban *et al*, 2010; Lal, 2010 & Young *et al*, 2015). On the other hand, Lal (2012) emphasizes that by maintaining productivity of the soil it reduces its degradation, which is a negative trend in land condition, that is majorly associated with human-based practices with both short and long term consequences including but not limited to reduction of biological productivity as well as ecological integrity (FAO 2005; Vlek 2010 & UNGA, 2013).

United Nation General Assembly (2015) revealed that soil security is of vital necessity particularly in ensuring that the pressure of growing human population does not decelerate the attainment of a food-secure world. Regrettably however, soil degradation has been critically noted to limit the soil quality (Vlek 2010 & Bir, 2019). The accelerated loss of arable land to soil degradation, which ultimately limits the level of farm yield, was declared a global concern (UNGA, 2013; UNGA, 2014 & FAO, 2015a), which is restricting sustainable development of economy of many countries (Gowing, 2008; Bindraban *et al*, 2012, Sayeed, 2013 & Chunyan *et al*, 2020), thus advancing the effect on food security (KFSSG, 2011 & 2018). Given that soil degradation is a major challenge that threatens global farming systems, Africa is no an exception in this case, particularly the Sub-Sahara regions (Zingore, *et al*, 2015). Studies on Africa's extent of soil degradation have established that soil loss is more than ten times higher in arid and semi-arid areas as compared to humid zones (Thiombiano, 2007 & Zingore *et al*, 2015). Further, Tully *et al* (2015) argue that in addition to other causes of soil degradation in Sub-Saharan Africa (SSA), increased and widespread agricultural practices in efforts to feed the growing population also plays a critical role. Bindraban *et al* (2012) specifically established that soil degradation in Africa is a consequence of unsustainable human actions including; intensive practices, poor agricultural methods in addition to poor soil conservation approaches (Keyzer *et al*, 2011, Zingore *et al*, 2015 & Tully *et al*, 2015).

Kenya is one among the many countries within the Sub-Saharan Africa region whose soil has been adversely affected by soil degradation (LADA, 2016). While this is the case, the importance of her agriculture is by far beyond the limits of domestic consumption, because it also contributes tremendously to the growth of other sectors of the Kenya's economy as a whole (Birch, 2018 & Eichsteller *et al*, 2022). This informs the efforts of Kenya's government to ensure that farm products are adequately available to her population with the hopes that this will contributes to the achievement of the famous blue print "Vision 2030", which is anchored on adequate food supply to eliminate food insecurity among her citizens (Jowi, 2016). Considering the historical analysis of agricultural production in the growth of Kenya's GDP between 2005 to 2015, the sector contributed between 45% to 51% of Government of Kenya's revenue, over 70% of both food and non-food agricultural-based raw materials for the industries as well as more than 60% of the foreign exchange (Rosemary & Alila, 2006; United Nation, 2019). During the same period, though agriculture was the greatest contributor in minimizing the level of poverty, productivity was low for cereals particularly maize (Wiggins, 2014; Wiggins, 2018 & United Nation, 2019). Further, considering the level of employability in various sectors of the economy, agricultural sector provided a higher more robust and diversified employment opportunities of almost 60% with over 80% of her population, especially rural-based households, sourcing their livelihoods chiefly from agricultural related activities (Jowi, 2016; Birch, 2018 & Boulanger *et al*, 2018). However, Kenya, just like any other developing nations, especially within the Sub-Saharan Africa, with agricultural based economies, most of her population resides in areas which are strongly vulnerable to soil degradation (Mulinge *et al*, 2016).

Accordingly, Muia & Ndinda (2013) noted that soil degradation is affecting economic livelihood of many people in Kenya. It does so by conditioning productivity of the arable lands which further exhibit ripple effect on food security (Wambua *et al*, 2014). The assessment of the extent of soil degradation in Kenya using Remote Sensing (RS) and

Geographic Information System (GIS) established that most parts of Kenya are facing the risk of various forms of soil degradation with Arid and Semi-Arid Lands (ASALs) highly affected because of the high soils erodibility coupled with increased intensity storms, surface run-off and soil erosion (LADA, 2016). These findings could be the reasons why Mulinge *et al* (2016) also noticed that the level of food crop production in Kenya has failed to exceed the country's ever growing food demand due to population growth rate. Homa-Bay County particularly, from which the study area has been extracted for the purpose of this study, has been given attention given that the county has a great agricultural potential which has never been achieved (County Government of Homa-Bay Integrated Development Plan, 2017) yet the county's food security heavily relies on its agricultural production (Auma *et al*, 2013; Nyamunsi, 2017 & Ambale, 2018) in the face of the county's rapid population growth rate of 2.7% (KNBS, 2019).

The Homa Bay County Integrated Development Plan (2013 – 2017) pronounce itself concerning some of the main development issues, challenges affecting Homa-Bay County, their causes, development objectives and potential strategic interventions as summarised in table 1.1. It shows that while there is declining soil quality coupled with low adoption of soil management and conservation strategies, the level of food insecurity is over 52%. There is a development objective to reduce it to 26% through strategies such as irrigation, use of chemical fertilizers, and improved seeds. The burden with these strategies is that while on one side strategies including irrigation can address the challenges of water insecurity (Odhiambo *et al*, 2022), on the other side studies have estimated that the application of chemical fertilizer and improved seeds may not be the ultimate solution to improved food crop production for their risk of limiting soil health in the long term

(Killebrew *et al*, 2010 & Krasilnicov *et al*, 2022) and even by extension they can increase the cost of production in the short and long term (Liverpool-Tasie *et al*, 2015).

Table 1.1: Analysis of Development Issues, Causes, Objectives and Strategies in Homa-Bay County.

Sector	**Causes**	**Long-term Objectives**	**Short-term Objectives**	**Action plan**
Crop /Livestock farming and Fisheries	Increased input cost; Poor farming methods; Unpredictable weather; Poor soil health; Poor adoption of soil and water conservation approaches;	To reduce the food poverty level in the county from 52% to 26%.	Encourage application of industrial fertilizer, Use of chemicals to protect the crops from pest and diseases; Use of irrigation in dry areas of the county; Encouraging soil and water conservation; Adopt drought resisting crops; mitigation	Extension services, Adopting suitable crops; Promoting irrigation farming (small scale irrigation); Advancing credit facilities to farmers; Avail more seeds for farmers for adoption; Establishing farmers' cooperative society; Establish model farmers; Collaborating/training of farmers groups;

Source: Homa Bay County Integrated Development Plan (2013 – 2017)

Many studies (Bindraban *et al*, 2010; UNGA, 2015; Boulanger *et al*, 2018 & KFSSG, 2018) opine that though food security has been a consequence of multiple factors such as climate change and its variability, biodiversity integrity, water security, pest and diseases as well as human health conditions such as effect of HIV/AIDS, it is important to note that sustainable maintenance of soil quality remain to play an important function in determining the level of crop yield. Further, whenever human adaptive measures such as irrigation, green house technologies, together with pest-disease control mechanisms have been employed to curb the effects of the aforementioned factors on food security like in the case of Table 1.1, more attention should be given to soil health to guarantee improved production (Ammari *et al*, 2015 & Adejumob *et al*, 2016). This study is particular with Rachuonyo North Sub-County, in Homa-Bay County because while her population is rapidly increasing and comes second, just after Ndhiwa Sub-County in Homa Bay County (KNBS, 2019), there is no assurance that the soil quality in the area is agriculturally viable due to the problems of soil degradation (Sikei *et al*, 2008; Opere *et al*, 2017; Abdalla *et al*, 2018 & Ambale, 2018). Considering intensified anthropogenic practices and paradigm shift in land use-land cover systems in the area, there is need to investigate effect of soil degradation on agricultural performance which is vital in addressing the importance of maintaining soil health in the face of such systematic shift in land use in addition to the pressure caused by increased human population in the study area.

1.2 Statement of the problem.

Smallholder farmers in Rachuonyo North-Sub-County have tracks of land that when cultivated should produce adequate food, mainly maize and sorghum, for subsistence consumption. This is because the area experiences average temperature and moderate rainfall which are perceived conducive for growing these crops. Additionally, the area residents can also grow groundnut, cassava, and sweet potatoes as supplementary food crops. It is however common to find that most of these large tracks of lands are uncultivated perennially while other farms are also characterized by wide and deep gullies. Additionally, food harvested particularly maize and sorghum last only between September and November, while the rest of the months are food insecure. The food shortage peaks between July and August (two months) as well as between December and March (four months). This implies that the total yield of which is on average of three to four bags of each 90kgs per acre is not enough for the area residents' population of about 178, 686 persons whose livelihood entirely depend on these crops as staple food.

What is worrying is that it is not evident that the soils in the area are agriculturally supportive as a result of soil degradation even as the level of food production reduces resulting to food insecurity threats among the households in the area. The evidences of soil degradation in the area include but not limited to accumulation of soils along the roads and other footpaths, field sheeting and gullying, bending of fences and electric poles, stone appearances on farms, and bare hill slopes. Regrettably, while soil degradation continues to accelerate coupled with low food production, there is scanty knowledge on how human-based practices may be influencing soil quality reduction with its ripple effect on food security.

It is worth to note that within the context of sustainable land-use practices, the absence of sustainable human-based practices relating to farming techniques, and proper soil utilization, is a threat in itself to soil health. This may go all the way to affecting agricultural production and by that an area is likely to face the risks of food insecurity. It is against this backdrop that this study sort to critically assess the common anthropogenic practices causing soil degradation and their resultant effect on food security situation among the area residents of Rachuonyo North Sub County, which will ultimately contribute to the development of sustainable land and water-use management practices in the county. This would also be imperative particularly to all stakeholders who are steering the development of appropriate and practical pathways of ensuring that the level of food security situation at both local and county level is enhanced on a lasting basis.

1.3 General objective.

The general objective of this study was to assess the effect of soil degradation on households' food security in Rachuonyo North Sub-County, Homa-Bay County in Kenya in order to improve health of the population while ensuring economic stability, and environmental sustainability.

1.3.1 Specific objectives.

i. To examine the main anthropogenic practices causing soil degradation in Rachuonyo North Sub-County.
ii. To establish the effect of anthropogenic soil degradation practices on food security in Rachuonyo North Sub-County.
iii. To investigate the most common soil management and conservation strategies in Rachuonyo North Sub-County.

1.3.2. Research Questions

i. What are the main anthropogenic practices causing soil degradation in Rachuonyo North Sub-County?

ii. What are the most common soil management and conservation strategies in Rachuonyo North Sub-County?

1.3.3. Research Hypothesis

i. HO_1: There is no significant relationship between anthropogenic soil degradation practices and food security in Rachuonyo North Sub-County.

1.4. Justification of the study

In the case of Africa, studies by (Thiombiano, 2007; Ye *et al*, 2009; UNGA, 2013; UNGA, 2014; UNGA, 2015; Zingore *et al*, 2015 & Mukherjee *et al*, 2018) have established close nexus between soil degradation and food security. While in Kenya, studies by (LADA, 2016 & Mulinge *et al*, 2016) have also established that vulnerability to degradation processes in many counties is high even in the face of declining production of cereals such as maize, sorghum, wheat, rice, and beans among others, which are the main staple food in the country. For instance, in Homa-Bay County where most households depend on maize and sorghum as their basic staple food, there is no assurance of food security (Nyamunsi, 2017 & Ambale, 2018). This is evident more in Rachuonyo North Sub-County which though have high agricultural potentiality (Abdalla *et al*, 2018) faces low crop production (Auma *et al*, 2010) even as cases of soil degradation in the area is also increasing (County Government of Homa-Bay Integrated Development Plan, 2013 & 2017). To address this situation of food shortage, therefore, there is need to examine the relationship between soil degradation and food security situation in the area of study by particularly assessing the impact of specific anthropogenic soil degradation practices on crop yield while exploring the possibility that they are causing food insecurity among the area households. This understanding is important in coming up with appropriate soil conservation and management strategies for controlling soil degradation to improve food crop production in Rachuonyo North Sub County on sustainable basis.

1.5 Significance of the study

The study findings will be helpful to the community members, county and national government as well as other stakeholders in the development of appropriate and practical soil security measures as a remedy for the risks of soil degradation and its environmental consequences. This is because it would provide strategic intervention technologies that the smallholder farmers can use to address the challenges of soil degradation and thus boosting their agricultural food production while enhancing their food security situation in the area on a sustainable basis. In addition, the findings would also help the County government of Homa-Bay in the development of legislation and regulations on environmental conservation and management.

Furthermore, the National Government of Kenya through the help of the local authorities would be able to initiate and even fund soil conservation projects in the area based on the findings of this study. This will in turn leads to the improvement of the agricultural performance in the area, which will ultimately enhance food and nutrition security while contributing to the achievement of vision 2030 milestones, and sustainable development goals (SDGs) particularly number 2, 8, 12, 13, and 15 among others that are either directly or indirectly linked to soil security vis-à-vis food security.

1.6 Scope of the study

This study was conducted in four of the seven wards in Rachuonyo North Sub-County in Homa-Bay County, which included West Karachuonyo ward, Kanyaluo ward, Kibiri ward and Kendu Bay Town ward. The wards were purposively selected based on the level of soil degradation and food insecurity. Food crops cultivatable in the area such as maize, sorghum, beans, sweet potatoes, cassava, and groundnut among others were considered as the main staple food for the area residents. The study focused on establishing the relationship between anthropogenic practices causing soil degradation and food security in the area. Lastly, when household farmers, taking agricultural decisions, have empirical knowledge about soil conservation and management, ideal for sustaining soil health, food crop production will improve hence solving food insecurity threats in the area of study.

1.7 Limitation of the study

This study was conducted during the period of Covid-19 pandemic which restricted not only movements but also out-door meetings. Because the study required high face-to-face contacts with the respondents, the researcher provided face masks and maximized on the use of hand sanitizers. The study was also conducted during nationwide fuel crisis which almost tripled the travelling cost. Since this study required far and wide movement from one household to another within the larger area of study, it was a real challenge to meet the cost of travelling. Nevertheless, researcher received more financial assistance from friends and family members which aided in meeting the travelling expenses for successful completion of this study.

1.8 Assumption of the study

While it is important to recognize the fact that soil degradation is a wide environmental phenomenon which can be induced by many factors that include but not limited to human, chemical, and physical processes, this study perceived human-based practices to have a lot of influence on soil degradation in the area of study. This is because for every human-based practice there should be practical knowledge towards soil utilization taking the center stage in controlling processes of soil degradation. The actions are also important in informing intervention strategies. Further, food insecurity can be a consequence of many variables such as over dependence on agricultural products, effect of pest and diseases, climate change, and human health condition yet this study linked it to soil degradation. It is strongly considered that when it comes to the questions of reliable agricultural performance, soil health is a major determining factor. Lastly, the decision to manage and conserve the soil is a function of human actions and its application to integrated soil fertility management approaches including farming guidelines, appropriate soil site-specific conservation measures as well as active participation of all stakeholders such as local residents, county and national government. This implies that the knowledge about man's practices on soil conservation measures can be combined with Integrated Soil Fertility Management (ISFM) to achieve a soil secure area.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review that relates to the nexus between soil security, soil degradation, human practices, and the overall effects on food security. The first part of this chapter deals with the perceived human based practices that fuel soil degradation, followed by their impact on food security, soil conservation and management measures, theoretical, conceptual framework and finally summary of the knowledge gaps.

2.2 Anthropogenic practices influencing soil degradation

Though causes of soil degradation appear not easy to understand, it is greatly perceived to be influenced by human practices (Alam, 2014 & Gomiero, 2016). LADA (2016) contends that the overall impact of human practices contributing to soil degradation majorly lead to increased erosion by wind and water, low water storage capacity, and increased surface run-off. Consequently, the broad effect of this is the low organic content available to the soil, biomass carbon, as well as decline in diversity (Alam, 2014). Further, soil use systems and additionally intensive practices which are less sustainable including sand harvesting, mining, quarrying, overgrazing, over-cultivation, and excessive forest conversion has also been realized to accelerate soil degradation (Kirui & Mirzabaev, 2014). This accordingly in the view of Gomiero (2016) contributes to continuous reduction in soil quality thus limiting soil productive capacity. It has also been established that while decline in soil health can be caused by both bio-physical and chemical degradation (Brady *et al*, 2008; Kumari *et al*, 2014; FAO, 2015a & Murtaza *et al*, 2016), the cost of human-based practices are perceived to increase pressure on the same. These result to various forms of soil wastage classified majorly as soil erosion due to increased surface run-off and in addition to this is depletion of soil nutrient as a consequence of unsustainable farming methods (Karlen & Rice 2015).

Accordingly, Murtaza *et al* (2016), the usually notable pointers of soil whose nutrient has been reduced are low soil organic content, deteriorated soil physical properties such as soil structure, soil texture, imbalance in soil nutrient status. Additionally, eroded soils are evidenced by both deep and rill cuts on the surface as well as sheet wash (Kirui & Mirzabaev, 2014). Though soil erosion is majorly caused by natural forces, it is highly acerbated by human-based activities like deforestation, poor farming practices like monoculture and unhealthy ploughing techniques such as along the hill slope as well as conventional tillage (Alam, 2014; Karlen & Rice, 2015 & Gomiero, 2016). This persistently accelerates reduction of soil productivity that can consequently lead to land abandonment. Plate 2.1 illustrates the extent of soil degradation by erosion in parts of Baringo County. It especially depicts the cumulative effect of soil erosion on the landscape, highly dissected surfaces, particularly those characterized by the low vegetation cover which leads to increased cases of degradation in an area.

Plate 2.1: *Part of a severely degraded area by soil erosion in Baringo County in East Africa*

Source: *Kenya News Agency (2018)*

This underscore the rationale behind the argument that the environmental forces including the action of water, wind, wave and glacial are chief agents of erosion while the speed and rate of surface run off is determined by first land topography and secondly the extent of vegetation cover (Summerfield *et al*, 1994; Orme, 2017; Ashiagbor, 2013, Kiage, 2013 & Murtaza *et al*, 2016) who also opined that soil structure and water holding capacity are significant determinant of soil erodibility. This implies that soil with weak developed structure, medium to fine in texture and having low content of organic matter are most likely to be eroded. Therefore, the understanding of soil erodibility in relation to its basic structure and other physical properties is central to its need for sustainable use. Table 2.1 is an illustration on how soil erodibility increases with decrease in percentage organic carbon. It shows that when the soil has low organic content, the pH value decreases and consequently it become vulnerable to processes of erosion.

Table 2.1: Classification of Soil Organic Carbon according to HWSD

Class	% Organic Carbon pH	Rating of erosion
1	< 0.2	Very high erodible
2	0.2 – 0.6	High erodible
3	0.6 – 1.2	Moderate
4	1.2 – 2.0	Low erodible
5	> 2.0	Very low erodible

Source: HWSD Database (2008)

Further, in relation to water holding capacity the table 2.2 illustrates how soil erodibility increases with decrease in average soil moisture content. This means that the saturated soil is more resistant to processes that accelerate soil erosion (Kumari *et al*, 2014).

Table 2.2: Classification of Soil Water Holding Capacity according to HWSD

Class	Water Storage Capacity (mm)	Rating of erosion
1	> 125mm	Very low erodible
2	125-100 mm	Low erodible
3	100-75 mm	Moderate
4	75-50 mm	High erodible
5	< 50 mm	Very high erodible

Source: HWSD Database (2008)

Furthermore, studies (Ashiagor, 2013; Fischer *et al*, 2018 & Panagos *et al* 2018), have documented that the extent of soil degradation poses temporal and geospatial characteristics. It means that the dynamics in the rate and speed of degradation change in terms of time and vary from one place to another. At the global level, soil degradation data revealed that degradation in Europe is about 60 to 70% (Feddama *et al*, 2001; FAO, 2005; Bagarello, 2017 & Fischer *et al*, 2008), and the Asian soil is about 40% degraded (Alam, 2014) while 65 to 75% of the Sub Saharan soil is degraded (Tully *et al*, 2015). However, in light of Zingore *et al* (2015), the causes of soil degradation that limits agricultural opportunities in Sub- Saharan Africa are mainly human based practices including but not limited to poor cultivation practices, deforestation, intensive livestock farming, and mining. It is based on these that the discussion about human based practices perceived to likely influence soil degradation is deemed important in adopting measures for controlling the situation. These perceived practices discussed herein include; deforestation and encroachment of forested land, monoculture and continuous cropping, convection tillage, cultivation on hill slopes, intensive livestock system, sand harvesting and stone mining.

2.2.1 Forests and bush clearing

Accordingly, forests have always been known to provide many important environmental benefits including conservation of soil (FAO, 2015a) as well as carbon sequestration (FAO, 2010a). However, there are many threats that come with the absence of vegetation cover in an area. Both (Dhar *et al*, 2004 & Kumar *et al*, 2013) observed that among other risks of clearing forest and other vegetation, the soil is the most affected directly now that it is deprived protection against erosion by both wind and water actions. They further argued that the decline of soil organic property signifies no or little mulching effect which is important in maintaining the health as well as fertility of the top soil.

Additionally, while IDP (2013) identifies deforestation as one among the many human-based practices resulting to reduction in vegetation cover hence causing soil degradation, Watt (2018) realized that human settlement in addition to intensive grazing on forested lands and hill slopes critically contribute to degradation of forest soils. Further, KIHBS (2006) argues that the very deforestation that causes the loss of vegetation cover largely manifests itself through clearing the bushes with an aim of expanding the land for crop cultivation and human settlement, firewood fuel and charcoal burning yet the resultant effect of this is the reduction in soil productivity leading to low crop yield thus likely to accelerate food insecurity situation. Studies such as Olagunju (2015) also observed that deforestation has both direct and indirect relationship with food insecurity (Figure 2.1) because it is directly causing habitat destruction and loss of biodiversity as well as indirectly through inducing soil degradation which consequently reduce agricultural production thus leading to food insecurity.

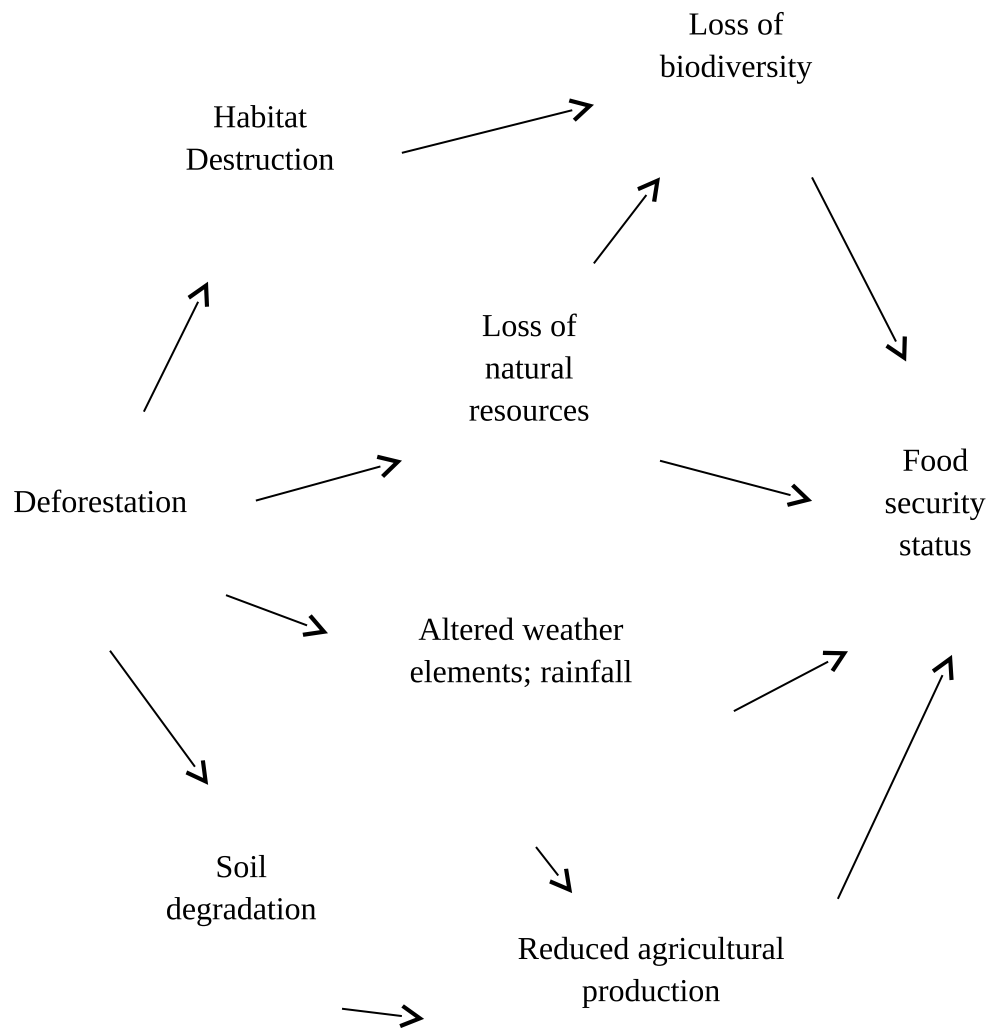

Figure 2.1: *Relationship between deforestation and food insecurity*

Source: *Olagunju (2015)*

However, such degraded soils according to (Childs *et al*, 2001 & Mutua *et al*, 2014) can be recovered by planting eucalyptus for its fast growth and other biological health benefits, Mukau (*Melia volkensii*) and Neem (*Azadirachta indica*) for their ability to grow fast and resist the effect of drought as well as suitability in soil conservation.

2.2.2 Monoculture and continuous cropping

According to Anelia *et al* (2012), different crops are known to have various soil micro-organisms while this rich diversity plays an important function in maintaining quality of the soil. However, monoculture and largely continuous cropping lead to soil quality reduction as they increase the over consumption of soil nutrients by the same type of plants (Killebrew & Wolff, 2010) and soil organic content (Marais *et al*, 2012 & Watt, 2018 & McKenna et al, 2020). This is as a consequence of increased human population which has caused high food demands therefore farmers have resolved to abandon or shorten fallow periods and crop rotation in favour of continuous production (Ehui *et al* (2005). The resultant effect of this has been accelerated effect on soil degradation (Killebrew & Wolff, 2010 & Anelia *et al*, 2012). This implies that the consecutive crop cycles deprive the soil its rich nutrients because growing plants take up more nutrients from the soil such as nitrogen, phosphoruos, potassium, and calcium (Ehui *et al,* 2005).

Harvesting of crops even worsen the situation because it leads to increased expulsion of these nutrients from the soil through crop residues (Anelia *et al,* 2012) thus the need to restore nutrients through fallow, leguminous crop rotations, and application of organic manure otherwise the soil may eventually develop nutrients deficiencies. Additionally, extensive cultivation of marginal lands has been increasingly accelerated by human population explosion (Zia-ur-Rehman *et al*, 2016). Coupled with shortages of lands, not forgetting reduced family farm sizes, as well as increased economic pressure, the farmers have resorted to intensive crop cultivation systems as adaptation mechanism in these areas while we know that this can lead to massive soil nutrients depletion which consequently results to loss of soil productivity (Karlen *et al*, 2015). Even though the quality and quantity of the crop production can be improved by use of industrial fertilizers that provide the lacking soil minerals (Kumar *et al*, 2013) their use has been established to deprive the soil other essential nutrients thus resulting to more soil degradation (Alam, 2014).

2.2.3 Conventional tillage and methods of cultivation

Soil tillage being a mechanical disturbance of the soil by means assumed to be land preparation aimed at improving crop production (Ngetich, 2008), it is notably an essential part of farm practices affecting the soil by reducing soil moisture content, soil thermodynamic, increased surface run-offs, infiltration, and evapo-transpiration processes (Busari *et al*, 2015). However, when carefully undertaken its importance include but not limited to loosening the soil which is key in enabling crop growth, suppressing the growth of weeds, eliminating insects and soil pathogens, proper soil drainage as well as mixing crop residue (Lal, 1997, Ngetich, 2008 & Mutonga *et al*, 2019). It is also based on its central role in seedbed preparation, leveling the soil in addition to incorporating all forms of manure and chemical fertilizers into the root zone (Karuma *et al*, 2016 & Wawire *et al*, 2018). Considering the effects of soil tillage both negative and positive influences, Ramzan *et al* (2019), have classified tillage practices into three main categories; first the conventional tillage which comprise of intensive deep surface cutting especially by use of modern machines like tractors, secondly minimum, reduced or conservational tillage to imply reduced soil disturbances cultivation practices majorly involving the use of tools like strip-till or chisel plowing, and finally zero tillage which is considered to have no soil disturbance.

Despite of a lot of literature focused on the discussion about tillage practices, much still needed to be done to improve the knowledge especially aiming at reducing the effect of convention tillage which accordingly (Ngetich, 2008, Busari *et al*, 2015 & Mutonga *et al*, 2019) maintain that has all along been contributing negatively to soil quality. This is because, as aforementioned, not only does it cause serious injury to the soil, disrupting soil structure, more surface runoffs and accelerated soil erosion (Ramzan *et al*, 2019) but also reduces crop residue, which help in protecting the soil against the force of heavy raindrops (Cornelis *et al*, 2013). While Lal (1997) observed that increased and intensive tillage reduces soil organic matter levels by causing reduction of organic matter in the soil, Killebrew & Wolff (2010) maintains that as soil organic matter declines soil become compacted, less able to absorb and retain water and this makes the soil prone to water loss through evaporation. In addition to this is the fact that without crop residue, soil particles become more easily dislodged hence splashed which clog soil pores, hence sealing off the soil's surface, resulting in poor water infiltration and this encourages surface run-off then the soil become highly vulnerable (Busari *et al*, 2015). The absence of knowledge among farmers about the importance of varying tillage as well as adverse effect of tractor tillage on soil security calls for an urgent and strategic study to come up with appropriate tillage system relevant to the area of study aimed at taking care of the soil health, plant growth and the environment.

2.2.4 Intensive cultivation and settlement on the steep slopes

While FAO (2015b) reported that people living on high elevated zones mostly in the developing countries are susceptible to food insecurity, poverty and malnutrition, accordingly, (Orme, 2007) Wubie *et al*, 2020) have found out that the level of soil degradation increases with increase in slope gradient particularly due to accelerated erosion by field run-off. This point out that the steeper the slope, the more the water action on a landscape. Therefore, the knowledge about slope gradient and soil degradation is important in planning the land use in first, hilly areas and secondly ASAL zones (Allison, 1993 & Meghadad *et al*, 2020). The high speed of water reduces the rate at which it's absorbed into the soil, while the more the water velocity the higher the dislodgement effect hence the greater the rate at which it is carried away (Wubie *et al*, 2020; Liu, *et al*, 2020). Additionally, as concave slopes are considered to erode more at the upper and steeper sections where run-off moves faster (Zhang *et al*, 2015), it is commonly agreeable that the longer the slope, the greater the water volume hence increasing in velocity as it runs off thus high potential to dislodging and transporting more soil particles (Wubie *et al*, 2020). Therefore, cultivation on the steep hill slope which is a common practice is likely to accelerate soil degradation by increasing rate of erosion. It does that by creating the path through which water flows faster down the slope hence initiating rill erosion (Moreno *et al*, 2010). This causes most soil particles to move down the slope during tillage under great gravitational influence. Hence, this acerbates the erosion and transportation of soil even on short slopes (Meghadad, *et al*, 2020). This means that the possibility that soil degradation is intensified when intensive agriculture is magnified on these steep slopes is quite high which in light of Acharya *et al* (2008) is a consequence of increased human population that piles pressure on an already scarcity land with the hope of resolving food demand. The soil therefore becomes vulnerable to soil degradation processes (Killebrew & Wolff, 2010 & Abdallah,*et al*, 2018).

2.2.5 Intensive livestock husbandry

Livestock farming has been an important part and parcel of many economies in the world which has been used as both short and long term solution to food scarcity throughout the ages (Weber *et al*, 2011). Promoters of sustainable land use (Salzman, 2004 & Cummins, 2009) essentially view livestock farming as successful an alternative and affordable means for survival within the marginal areas and other zones which are less agriculturally productive. However though, the estimated rate of plant recovery in an area has been discovered to be greatly controlled by the level of livestock density at any given time (Weger *et al*, 2011). This view is also maintained by Cummin (2009) who additionally opines that high number of livestock and more time spent while grazing in a certain area before relocating to another decreases the pace of plant recover. This leads to loss of biodiversity which ultimately causes soil degradation (Salzman, 2004 & Lambin *et al*, 2009 & Weger *et al*, 2011). While many academic attention and a number of research findings have over long time recognized the positive inputs of livestock in the agricultural system particularly in developing nations as more beneficial and sustainable (Lekasi, *et al*, 2001), which is indisputably sounding, however, intensity livestock system notoriously continues to impose risks to soil health (FAO, 2006). This is so given that increased animal farming adds pressure to the grazing lands which accelerates cases of soil erosion, formation of hard pan on the soil, and generally other elements of environmental degradation (Ehui & Pender 2005). They also maintained that increased 'hoof action' of the livestock continuously contribute to compaction of wet soil thus making them less able to absorb water, increased risk of erosion and surface run-off. Then it is unlikely that the resultant effect of intensive livestock keeping is positive.

2.2.6 Intensive sand harvesting

Sand harvesting, as practiced in parts of Migori county shown in Plate 2.2, is considered as one among the most important economic activities which according to Mungai *et al* (2000) is globally practiced both in countries with developed economies as well as those with developing ones though the environmental problems occur when the volume of its extraction supersedes the rate at which it is being replenished (Saviour, 2012).

Plate 2.2: *Part of Migori's sand harvesters destroying farm lands*
Source: *Kenya News Agencies (2018)*

In relation to the context of the preceding findings on sand mining, the extraction of sand has been noted to account for the largest amount of solid materials from the earth after water (Chilamkurthy *et al*, 2016). Ashraf *et al* (2011) contend that the problem of soil degradation can worsen when the global monitoring of sand extraction is compromised, a phenomenon which has been largely witnessed particularly in Europe and Asia. Extensively, sand harvesting has been noted to impose a lot of social and economic risks such as low agricultural production, school dropout, community conflict, and even accidents due to landslides hence causing deaths mostly in the African countries including the coastal regions (Chilamkurthy *et al*, 2016 & Mngeni *et al*, 2016).

In Kenya, for instance, sand harvesting is for commercial consumption, practiced both in counties which are more urban or located near major urban centers (Nthambi & Orodho, 2015). They associate this with mainly rapidly growing populations in such urban areas which lead to mushrooming of more construction industry because there is unprecedented demand for sand material for building and construction to meet the housing demand for the ever-rising human population. Though, studies such as Saviour (2012) have established that the cumulative effect of sand harvesting is the destruction of the topography of the land, rapid soil degradation which may possibly reduce soil productivity, Ouma (2020) advocates for strategies that encourage sand exploitation because in his view, the benefits of sand harvesting supersede the environmental risks.

Nevertheless, in spite of this overwhelming contradiction, Mungai *et al* (2000) established that in addition to other challenges caused by sand harvesting, storage of sand causes ‘burning effect’ on the surface areas thus impact negatively on vegetation. They also argue that such soil remain agriculturally non-viable because the economic value of the soil is significantly reduced. It therefore follows that whether beneficial or problematic, sand mining being one of the economic activities widely practiced in various parts of the area of study, should be studied exhaustively to establish its impact on soil health to find out its relation with food security situation in the area of study.

2.2.7 Stone mining

Stone mining just like sand harvesting is also important socio-economic activities which support many livelihoods (Chilamkurthy *et al*, 2016 & Bewiadzi *et al*, 2018). It is required mainly for building and construction both in rural and urban centers (David, 2018). Bewiadzi *et al* (2018) opines that the spatial distribution of quarrying is generally even, that is, there are hardly any mountain settlements without a quarry, of any scale, opened in their surroundings. The rapid growth of building and construction activities (Nthambi & Orodho, 2015), to align it with the present human demand for more housing together with societal need of infrastructural expansion (Mngeni *et al*, 2016 & Ming'ate *et al*, 2016), ultimately increases the demand for gravel. Presumably, this may justify the believe that stone mining signifies growth and growth signifies economic mobility. However, Langer (2001) found out that there are several negative effects associated with gravel extraction especially if the practice is intensified.

In light of Wangela (2019), quarrying is not healthy for the environment in several ways such as interruption of the continuity of open space, air and dust pollution, deterioration in water quality, and ruining habitats for flora and fauna, but more importantly it has advance effect on soil degeneration. This can never be underestimated and therefore the need to regulate stone extraction both in Kenya and abroad. In Kenya, the impact on quarrying on human and environment according to Ming'ate *et al* (2016) can be addressed through a number of approaches including the use of technologies that are friendly both to the environment and human, rehabilitation of quarries with the hope that it may help in sustaining and improving livelihood that depend on stone quarrying.

It then implies that while on one side the importance of stone mining positively relates to its socio-economic benefits, on the other side are negative consequences including soil degradation which will affect food security. Therefore, approaches to balance the economic importance of stone mining while controlling its environmental effects particularly soil degradation are needed. The local residents, whose livelihoods partly depend on gravel extraction as part of their economic activities, like in the case of the area of study, should be enlightened about its long term consequences on agricultural performance. Instead, they are missing it on an alternative income generating activities such as fishing particularly fish farming, and fruit-tree agriculture, among others, which in addition to their economic benefits, they are also environmentally sustainable.

2.3. Impact of soil degradation on food security

Food security according to FAO (2000) is when all people are able to access food in proper proportion of nutrients, and qualitatively safe for human consumption for a healthy life. It can be measured at five major levels that are individual, household, national, regional and global levels (FAO, 2013). The focus of this study was on food security among the area residents of Rachuonyo North Sub-County, measured qualitatively at the household level. Accordingly, studies (IFPRI, 2008; FAO, 2010b & Maxwell *et al*, 2013) opine that food security measurements should focus on primary food components including variety of dietary content and frequency of access. Under this category, potential indicators for investigation in relation to this study include amount of food available depending on the opinion of the households and prices of foodstuff. Further, the second measurement is based on the consumption behavior, which according to Wiesmann (2008), is an indirect measurement of food security. In relation to Wiesmann (2006), consumption behavior considers the behavioural preferences of people which encompass adaptive and coping options people engage in when they do not have enough food or money to buy food.

The coping strategies examined in relation to this study included school absenteeism, domestic violence, and dependence on relief food. Relief food programs particularly in schools are envisioned on improving and maintaining high level of school enrolment, attendance, learners' retention in addition to completion of school among the school-going children (Government of Kenya, 2016). This implies that school absenteeism and relief foods, for an example, point out to one another as indicators of food insecurity in such a manner that where there is absenteeism among school-going children, relief food program strategies are partly employed as intervention strategy. Whether dietary diversity, food frequency or consumption behavior, studies including (Marques 2003, FAO, 2019 & Mutea *et al*, 2022) categorize these food insecurity indicators as economic shocks. Economic shocks in the understanding of these studies include but not limited to unpredictable rapid rise in food prices, and collapse in the level of income among the household members. These in the long term reduce the household abilities to maintain food security (Mutea *et al*, 2022).

The major challenge facing many countries today is the problem of food security including uncertainties in its availability, accessibility, utilization as well as stability which are the pillars for a food secure world in the face of a rapidly growing population (FAO, 2000; Utuk & Daniel 2015). The global human population touched about 7.7 billion in 2019 (United Nation, 2019). It added one billion people since 2007 and approximately 2 billion since 1994 (Oyekale, 2001). Though there is high level of uncertainty in population projections, there is certainty of 95%, that the global population is likely to hike to nearly 8.6 billion in 2030, 10.1 billion in 2050, and roughly 12.7 billion in 2100 with Sub-Saharan Africa countries projected to have the highest population around 2062 (United

Nation, 2019 & Gu *et al*, 2021). In Kenya, the country's population situation analysis reveals that the increasing number of people as a result of high population growth rate and the existing demographic situation implied by influx of youth population provide challenges to the economy of the country such as vulnerability to food insecurity (Government of Kenya, 2013). In such a situation therefore, the food demand implies to be floored below the population growth rate. It is therefore imperatively important to evaluate the potential causes of this phenomenon which accordingly, this study implores the level of anthropogenic practices causing soil degradation with the aim of establishing the extent to which they could be fueling food scarcity situation among the area residents, at a time when rapidly growing population is witnessed in Rachuonyo North Sub-County.

Globally, while the level of soil quality literally controls the level of agricultural performance, soil degeneration is one among the many essential causes of low farm yield (FAO, 2015a). The reduced soil quality negatively affects the environment and economic growth of countries as well as food security situation (FAO, 2018). The effect of soil degradation implies that there is less assurance of the future availability of arable lands and soil quality (Bindraban *et al*, 2012). This according to Tiziano (2016) means that food supply disruptions will become more frequent therefore food insecurity will increase if soil degradation is not contained. In Sub-Saharan regions, soil degradation threatens food production especially due to growing human population. Regrettably however, population growth and soil degradation do not signal any sense of impending danger to human race and livelihood while their actions are procrastinated to give space to what are narrowly seen as urgent needs (Bindraban *et al*, 2012). The resultant effect is therefore chronic food insecurity because soil degradation according to Tiziano (2016) can generate 'selfreinforcing feedbacks' that cause the situation to persist and worsen. This occurs especially when both agricultural and non-agricultural decisions, taken by the stakeholders including household farmers, to address the economic constraints are not sustainable along with the problem of inadequate capital investments to adopt soil management and conservation practices (Ocelli *et al*, 2021).

Hence, while moving agriculture from the primary cause of soil degradation to sustainable soil restoration practices requires proper knowledge, time and money, there is knowledge gap and inadequate resources concerning this need about the area of study, particularly in relation to establishing cause-effects relationship between soil degradation and food crop production. Therefore, this informs the main interest of this study with the hope that when soil degradation is controlled through sustainable human practices, food production will increase to support the growing population whose livelihoods mainly depend on farm produce.

2.4 Common soil management and conservation measures

This study is anchored on the premise that the practical knowledge of the smallholder households about management and conservation of soils as a natural resource is imperatively essential for sustaining environment health, human livelihood as well as other general well-being. This is because soil degradation can be mitigated and its consequences reversed. In fact, Di Stefano *et al* (2006) critically opined that though soil degradation is a phenomenon which is unstoppable, its mitigation is possible, necessary and by extension mandatory. According to Bagarello (2017), to achieve protection of soil against soil degradation therefore, the establishment of how soil quality is lost by field-based practices in a place at a given time interval is fundamentally required. Therefore, there is need to implement effective and economically sustainable soil conservation measures which according to Ocelli *et al*, (2021) is one of the important and honourable actions to take and largely achievable when household heads, taking agricultural decisions, have the requisite knowledge in soil management and conservation which can be acquired through three dimensions of learning such as home learning, social learning and education. By so doing that, in light of Lal (2012), the importance of sustainable management, as a royal path to sustainable governance of soil resources, will be realized.

There have been attempts towards establishing soil management and conservation strategies to address the problem of soil degradation though failure has been witnessed in some while others have had some success (FAO, 2000 & KALRO, 2020). The most successful measures according to Oluwatosin *et al* (2020) have been field-based approaches including inducing cover cropping and use of mulch materials, crop rotation, minimum tillage, ridges cultivation, construction of terraces, as well as planting windbreaker trees. FAO (2017) also views the idea of cover cropping and careful use of mulch materials as weightier and effective in maintaining the top soil. This can be achieved by leaving behind a crop residue over the soil largely to reduce soil dislodgement and displacement as a consequent of heavy raindrops on the soil particles, before decomposing, as well as checking the amount of runoff and water velocity over the soil (Oluwatosin *et al* 2020). Additionally, close to this, the importance of enhancing agroforestry can never be underestimated when it comes to mitigation against soil degradation (Vanlauwe *et al*, 2006a & Vanlauwe *et al*, 2006b). A well-designed and managed agroforestry systems as well as proper vegetation cover can control the run-offs, ensuring soil organic matter is available to the soil thus promoting soil nutritional requirements all the time and additionally aiding in managing soil structure and texture (Sarvade *et al*, 2019).

Further, the benefits of crop rotation is not limited to only minimizing the effect of pests and disease outbreaks but also ensuring sustainable management of agricultural systems, oblivious of the future through enhanced soil health (FAO, 2017). Moreover, soil structures are also improved, increased soil organic matter and efficient rooting system especially when secondary crops such as but not limited to beans varieties, cassavas, sweet potatoes, and peas varieties are also incorporated in the rotational cropping (Vanlauwe *et al*, 2006a). Minoshima (2007) also maintains that conservation tillage as a less destructive tillage is an important method for protecting the physical properties of the soil while ensuring that crop residues are adequately available to the soil. Construction of ridges, terraces and contours are ideal in supplementing other methods of soil conservation especially is hilly areas (Oluwatosin *et al*, 2020). In their view, the ridges should be made along the contours as trap strips, positioned to the direction of the moving water and wind to control their actions, reduce their speed as well as intercepting soil particles.

Further, as planting windbreaks as barrier, deflecting the air and reducing wind speed, residue management which is the most preferred method for controlling soil degradation (Vanlauwe *et al*, 2011), comprises of many actions like varying tillage practices to maintain residue from the previous crop harvest (FAO, 2000 & Minoshima, 2007). As well, it also retains mulch materials left either standing or lying flat purposely to intercept soil grains, by stopping them, and in so doing, soil water storage is improved even if there are run-offs, increased rain-water infiltration and reduced rate at which soil moisture is lost to evaporation (Oluwatosin *et al*, 2020). Conversely, the application of chemical fertilizer conditions soil quality hence is resulting to low soil quality (Abongo *et al*, 2014; Singh & Raghubanshi, 2020). Therefore, organic based agriculture is an ideal substitute because it leads to ensure both soil physio-chemical and biological properties particularly to tropical soils (Vanlauwe *et al*, 2010). Increasing the soil organic carbon content to an already degraded soil improves the overall soil quality (Vanlauwe *et al*, 2011).

In addition to field base soil conservation practices, there are many institutions particularly in Kenya, both public and private, involved in soil management each with their specific Acts that give them their mandates (KALRO, 2020). These acts include but not limited to Arid and Semi-Arid Land Development Policy 2014, Land Act 2012, The Agriculture Food and Authority (AFA) Act No. 13 of 2013, The Kenya Agricultural and Livestock Research (KALRO) Act, 2013, and Crops Act, 2013 among others. However the most challenging part of these acts is the rigidity as well as overlapping roles which have led to duplication, confusion and conflicts of interest among the institutions (Esilaba, *et al*, 2021). This therefore may causes weak coordination, implementation and enforcement of existing environment and natural resources policies and legislation which in this case is evident. The universal concerns for environmental protection and soil degradation requires that attention should be on the introduction of adequate but less punitive legislation and well-coordinated institutions for preventing or controlling soil degradation. The effective application of laws on soil conservation should be viewed within the broader context of dynamics in land use planning and horizons (FAO, 2015a) which is essential to agricultural practices. Laws such as Convention on Biodiversity are good and relevant to soil conservation because biological community is an essential characteristic of a healthy soil (Hannam, 2021). Such laws promote the use, fair distribution and equitable sharing of the benefits gained from utilizing environmental resources. They consequently contribute to the management of other components of the environment such as soil (FAO, 2015a & Esilaba, *et al*, 2021). Therefore, though laws and legislations are important, they should be more flexible, inclusive, and sustainable as well as exhibit high level of internal suitability in their application to soil management and conservation.

Human practices influencing soil degradation are never uniform, that is, they vary from one site to the other. In this regard, the application of site-specific management of soil degradation is deemed important (Corwin, 2013). Being an important soil management approach it is sensitive to regionalizing control of anthropogenic causes of soil degradation (Corwin, 2013; Carter & Johannsen, 2017). Its success according to Vanlauwe (2015) springs from systems of management which includes farmer's capacity to vary tillage and farm inputs depending on soil conditions and needs. Many studies including (Vanlauwe *et al*, 2010 & Corwin, 2013) established existing dependence between the site-specific soil Management and Integrated Soil Management and treated them as complimentary approaches to one another. While the former considers soil conditions such as soil texture, soil structure, soil organic content, moisture content, and soil pH value, the latter is a mechanism of addressing the geospatial variation in soil components (Vanlauwe *et al*, 2001; Masila, 2013; Karlen & Rice, 2015).

2.5 Theoretical Framework

The Theory of Praxeology was considered relevant to this study. Praxeology as a theory of social science concerning human action or practice it derives its origin from the concerns of Greek's philosophy of morality, especially the Aristotle, with emphasise on knowledge to serve human well-being to ensure self-fulfilment (Caldwel, 1984 & Hieber, 2017). Human well-being according to (Defoer, 2000) interpretation of praxeology, requires a set of human endeavour combined with action (praxis) while human endeavour relates to reasoning ability and rational learning to acquire empirical knowledge, acts which are more ethical along with wisdom-based experience. This theory involves bringing together of knowledge and action which implies practical application of knowledge. The praxeological 'practices' refers to demonstrative knowledge while this knowledge implies learning as a consequence of action contrary to psychological 'actions' which comes after learning (Caldwel, 1984 & Defoer, 2000).

While the term was first used in 1890 by Alfred Espinas who applied praxeological analysis to the study of social sciences, the main proponent, Mises Von Ludwig, contextualized praxeological study to establish the gravity of human choices in both economics and social sciences in 1946 (Gasparski, 1996). In his book 'Human action; a treatise of economics' he popularised praxeological economics as a discipline in social science purposefully aimed at investigating consequences of economic actors taking action including consumption behaviour, deliberately making consumption choices depending on preferences, and other factors such as incentives under free market economy. Since then, the theory of praxeology has been used to study disciplines such as political science, linguistics, sociology as well as economics and its related sub disciplines including but not limited to political economics, agricultural economics, and geographical economics which basically details the logic behind human choice and course of actions. Praxeology draws attention to the production and practical (scientific) use of knowledge (Nas *et al*, 1987, Wardenga, 2013 & Hieber, 2017), action aspects in praxeology being more of intervention strategies (Martin & Sunley, 2022). For this reason Defoer (2000) opines that both experience and practice (action) address aspects of the intervention while these interventions are based on pre-set objectives and available scientific knowledge.

Accordingly, (Hieber, 2017) maintains that while the most considered assumption of praxeology is the fundamental postulates of human action that all actions are rational, the strengths of praxis reasoning in addition to being perfectly certain and incontestable, they are also conveying exact and premise knowledge of real things. However, he contends that a priorist reasoning is purely conceptual and deductive hence not able to produce anything else but analytic judgement, that is, all the implications are systematically derived from pre-determined premises thus very rigid.

The praxeology provides the guidelines and new insight for understanding the choice for human practices and their environmental consequences which provide diffusible learning outcome, to achieve the desired transformative goals for agricultural revival through integrated soil fertility management (Boge, 2021 & Rad *et al*, 2022). Therefore, there is need to produce a praxeology for integrated soil nutrient management and conservation because it provides essential elements which are relevant for application to such approaches (Deugd *et al*, 1998; Martin & Sunley, 2022). The referred essential elements are broadly classified into action, diffusion and evidence of effect of change, all being a consequence of one other. This implies that praxeology aims at the farmer taking an action, increasing the smallholders' knowledge and lastly diffusing the acquired knowledge (Wardenga, 2013).

In relation to this study, human endeavour (practice or action) based on the desire to fulfil the current existing economic needs such as food, considerably results to soil degradation which consequently limits agricultural opportunities thus food insecurity. It is as a result of this chain of consequences that provides learning opportunity to human being to re-direct his energy towards adopting soil fertility management practices. He starts to perceive soil nutrient management as a set of practices including the use of soil organic matter together with the knowledge of adapting them to the local conditions, aimed at optimizing its efficiency in improving crop productivity. Additionally, there is increasing understanding to involve the multiple use of woody and other legumes in growing crops primarily to increase the availability of organic materials, more crop yield as well as scaling farm profits (Vanlauwe, 2003) which according to Sanginga *et al* (2003) are sustainable agricultural revival practices. The knowledge of advancing the efficient use of available soil nutrients together with decent agro-based practices such as timing planting seasons, with appropriate densities of crops, as well as sustainable weed control measures are critically beneficial in ensuring cautious use of industrial fertilizer (Kalkhoran, 2020 & Fairhurt, 2012). This is because the claim that the mineral fertilizers are the only and absolute solution to containing the problem of soil fertility is less sensitive to its challenges as first it deprives the soil essential natural nutrients and secondly should there can be a chock in the supply chain of these fertilizers to the developing nations, there will be no further agricultural investments (Hilhorst & Toulmin, 2000). Hence there is need for imaginative and adaptive approach to the problem. The knowledge how organic resources are essentially vital in maintaining soil health informs their decision to introducing secondary crops and high value vegetables into practice given that they can greatly boost soil organic content (Defoer, 2000; Sanginga *et al*, 2009 & Fairhurt, 2012).

Diffusion stage is one of the major learning points regarding this theory. It entails the spreading of the knowledge on a resident to a resident basis. Every individual, young or old, within the area should successfully receive the information about technologies involving soil management. This provides a local network in its continuous application which is the basis of competent learning and transfer of new insight. The government has a role in strengthening the efforts of the local residents through provision of financial support and education services. Finally, the last stage is the evidence of effective change. There should be evidence of effective change including improved soil quality, reduced effects of surface run offs, as well as improved crop production hence a food secure area.

In the field of geographic research, this theory has been widely used successfully in the study on studying about integrated soil fertility management in Sub-Saharan Africa (Defoer, 2000). In the study, the researcher detailed how human practical experience concerning soil degradation informs their decision to act as an active agent of soil conservation. It has also been used to study about the evolutionary geographical economics (Martin & Sunley, 2022). Therefore, in this study, considering human practices as one of the major cause of soil degradation which consequently lead to food insecurity, praxeology is an ideal conceptual thought on acquisition of practical knowledge for learning technologies relevant to soil management and conservation as a stop gap measure against the consequences of such human actions.

2.6. Summary of the Knowledge gaps

From the reviewed literature, it is evident that studies on causes of soil degradation including anthropogenic practices have been done (Alam, 2014; Zingore *et al*, 2015 & Murtaza *et al*, 2016). Further, soil degradation has also been identified to reduce soil quality which consequently threatens food security situation (Vanlauwe *et al*, 2011; Bindraban *et al*, 2012 & FAO, 2015a). However, the relationship between human-based soil degradation practices and food security among small scale farmers particularly in relation to the area of study is not evident. Therefore, there is need to carry out this study with the aim of adopting soil conservation intervention strategies including sustainable farming technologies, better management of soil organic content through ISFM, promoting legumes-based ISFM practices for controlling soil nutrient depletion, controlling pest and diseases, as well as integrating the knowledge, of the smallholders in the area, relevant to soil management and conservation practices to improve soil quality for better production.

2.7 The Conceptual Framework

In light of the conceptual framework (Figure 2.2), anthropogenic soil degradation practices are the independent variables (IVs) while food security situation is the dependent variable (DVs). Within the context of this conceptualization lies the view that anthropogenic activities are perceived to be causing soil degradation in Rachuonyo North Sub-County. The main practices such as continuous cultivation particularly maize and sorghum, hill-slope cultivation, intensive livestock farming, convectional tillage mainly tractor farming, tree and bush clearing, sand harvesting, and stone mining are investigated to establish the most commonly causing soil degradation and the extent to which they impact on food security situation in the area. However, elsewhere, there have been studies linking food insecurity situation to other factors such as climate variability, water insecurity, human health conditions such as effects of HIV/AIDS, reduction in biodiversity integrity, gradient of the slopes as well as effects of pest and diseases which according to this study are the extraneous variables. To achieve the need for improved food security situation in the area, this study perceives intervening variables as stop gap measures against food insecurity. The intervention strategies such as embracing organic farming, adoption of conservational tillage, adoption of agroforestry, afforestation and reforestation, rotational farming, gazettment of forests, periodic community education, and digitalized sensitization are deemed as ideal and urgently necessary.

Independent Variables

ANTHROPOGENIC SOIL DEGRADATION PRACTICES
Monoculture
Steep slope activities
Livestock husbandry
Conventional tillage
Trees-bush clearing
Sand harvesting
Stone mining

Reduce

Dependent Variable

HOUSEHOLDS' FOOD SECURITY SITUATION
Indicators;
Food prices
School absenteeism levels
Domestic violence level
Malnutrition levels
Relief food dependency level

Action

IMPROVED FOOD SECURITY

Indicators;
- ✓ Affordable food prices
- ✓ Improved human health
- ✓ Reduced domestic violence
- ✓ Improved school attendance

EXTRANEOUS VARIABLES
Water insecurity
Reduced biological integrity
Climate variability
Health condition
Pest and diseases
Gradient of the slope

INTERVENING VARIABLES
Organic farming,
Agroforestry
Planting trees
Rotational and mixed farming
Homa Hills cut-lines
Forest gazettment
Community education
Conservational tillage
Digitalized sensitization

Figure 2.2: *Conceptual framework showing the relationship between the variables*

***Source**: Author (2022)*

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter entails research methodologies that are relevant to this study. It presents the discussions of different sections on research design, study area, study population, sample size, pilot study as well as data processing and analyses techniques.

3.2 Research Design

While Castellan (2010) argued that research design is the process of applying an empirical test to support or reject a claimed knowledge, Pandey & Mishra (2015) maintain that the concept of research design majorly entails the working plan for a study that is used in guiding collection and analysis of the data. Kothari (2009) further opines that research design is the conceptual structure and simple procedures for collecting and analyzing data to address the purpose of the research. Considering these views therefore, it is clear that both Kothari (2004 & 2009) as well as Pandey & Mishra (2015) collectively agree that research design is a blueprint that is followed by a researcher in completing a study.

Therefore, for the purpose of this study, cross-sectional survey design was used. According to Levin (2006), cross-sectional studies are carried out in most cases to investigate relationship between independent variables (risk factors variables) and the dependent variables (the outcome of interest) which in this case is one of the primary intentions. This research design has been widely and successfully used to study awareness of the urban residents about climate change as well as their adaptive behaviour and mitigation measures

(Okaka *et al*, 2018) and elsewhere in a study on Irish potato production in relation to climate change (Ndegwa *et al*, 2020).

The collected data for this study were both quantitative and qualitative which according to (Creswell 2014 & Yong *et al*, 2015), is basically mixed approach where qualitative research is used to explore the meaning of individuals or groups of social or human problem while quantitative research studies involves acquiring, testing and reporting statistical significance through a null hypothesis. In the case of testing hypotheses, Zadrozny, *et al* (2016) emphasize the fact that significance testing is the most popular way to show how much the results are worth paying attention to.

3.3 The study area

The study was conducted in Rachuonyo North Sub-County in Homa-Bay County, which has seven wards that includes West Karachuonyo ward, North Karachuonyo ward, Kanyaluo ward, Kibiri ward, Wang'chieng ward, Central Karachuonyo ward and Kendu Bay Town ward. The area is located within the longitude 34^0 30'W and latitude 0^0 25' S. Rachuonyo North Sub County (Figure 3.1) borders Rachuonyo South Sub-County to the East, Homa-Bay Town to the South and Lake Victoria to the west which also extends towards the northern section. According to County Government of Homa Bay Integrated Development Plan (2013-2017), the physical and topographic features of the Rachuonyo North Sub County can be divided into two main relief regions namely; the lowlands lakeshores and the upland region. The lakeshore lowland is between 1,163 –1,219 m above the sea level with a narrow stretch bordering the Lake Victoria especially in the west and northern parts of the sub county. The upland plateau starts at approximately 1,219 m above the sea level and has an undulating surface due to erosion of an ancient plain, while the highest peak is found on the highland of Homa-Hills.

The Ministry of Agriculture, Livestock and Fisheries; State Department of Agriculture (2014), showed that most parts of Rachuonyo North Sub County have black cotton soil with hydrogen potential value (pH) ranging from strongly 4.76 to slightly acid 6.32. Farmers in this area can apply farmyard or compost manure regularly to maintain and sustain the organic matter content. Further, the area has soils with low fertility, poor drainage as well as inadequate soil organic matter content, characterizing most parts hence resulting in low WHC and low rate of water infiltration which may consequently lead to soil erosion by run-off surface water during the torrential rains (MOALF, 2014 & Ochieng *et al*, 2017). The climate features of the area of study are a tropical humid and strongly dominated by the influence of Lake Victoria. This is because the humidity is notably high and the evapo-transpiration rate is between 2000 and 2200mm per year (Opere, 2016; Ochieng *et al*, 2017). The annual temperature in Rachuonyo North Sub-County is also noted to be ranging from 17^0c to 34^0c indicating that the area receives moderate to high temperature annually (Ochieng *et al*, 2017).

Figure 3.1: *Map of Rachuonyo North Sub – County showing Administrative unit*

Source ***:*** *Author (2022)*

3.4 The target population

The study population was 32,500 households (KNBS, 2019) drawn from West Karachuonyo, Kibiri, Kanyaluo and Kendu- Bay Town ward. The households were considered given that first nearly all families in the area of study depend on food crops farming as their main source of livelihood and secondly food crops such as maize and sorghum are their main staple food (County Government of Homa-Bay, 2017). The population is unevenly distributed in Rachuonyo North Sub-County; the average family size is about four persons per family while the population density is approximately 410 persons per square kilometer (KNBS, 2019).

3.5 Sample size and Sampling procedure

The four wards were purposively selected from the seven wards in the area of study based on the intensity of soil degradation (County Government of Homa-Bay Integrated Plan, 2013 & 2017) while Cochran formulae (1977) was used to obtain a sample size such that

$$n = \frac{z2(pq)}{e2}$$

Where ‘n’ = Sample size.

‘z’= Table value at confidence level 95% was 1.96

‘p’ = Standard error associated with the chosen level of confidence 0.25

‘q’ = 1-p

‘e’ = Acceptable sample error.

The acceptable sample error used is specified at 5% while the variability was 25%.

Therefore, the sample size of 289 was arrived at as follows;

$$n = \frac{(1.96)(1.96)(0.25)(0.75)}{(0.05)\text{¿¿}}$$

$$\frac{(3.8416)(0.1875)}{0.0025}$$

n = 289

The study then used a multi-stage cluster sampling technique in a manner that in the first stage the four wards were considered as four clusters which included; West Karachuonyo, Kibiri, Kanyaluo and Kendu- Bay Town ward. In the second stage, data on average family size and total population of residents of each cluster which were obtained from Rachuonyo North Sub County Ministry of Agriculture were used to generate the sample frame (Table 3.1). Simple random sampling was used in the third stage, to draw the samples from each sub-group and finally the sample size from each cluster was expressed as a percentage of the number of households from each ward to establish the level of representation.

Table 3.1: Sampling Frame

Wards	**Population**	**Households**	**Sample Size**	**%tage**
Kendu-Bay	22,463	7,872	70	0.83
Kibiri	21,498	7,535	67	0.90
Kanyaluo	20,603	7,084	63	0.95
West Karachuonyo	28,746	10,009	89	0.90
Total	**93,310**	**32,500**	**289**	**0.89**

Source: Author (2022) adopted from KNBS (2019)

3.6 Methods of data collection

Both qualitative and quantitative data were collected during the field work across the four wards in Rachuonyo Sub-County. The data were collected by use of; structured questionnaire, observation schedule that were moderated with the help of my colleagues and supervisors. Additionally, Key Informants were interviewed and Focus Group

Discussions sessions at ward level were conducted to supplement the other methods of collecting field data.

3.6.1. Questionnaire

This study used questionnaire as the main data collection method. Questionnaire consist of a number of printed questions or rather typed questions in a clear order on a set of forms while the respondents are limited to only responding to the questions in written format (Mulusa,1988 and Kothari, 2004). It is the commonly used method in case the researcher has limited resources while interested in collecting massive field data within a short period of time. With these advantages in mind, its application in research has been far and widely relevant to many researchers' works including (Masila, 2013, Okaka *et al,* 2018, & Ndengwa *et al*, 2020). For the purpose of this study, this method was used to collect data from the farming families within the area of study. It was helpful in collecting data on major and dominant human practice that are likely to threaten soil health in the four wards within the area of study, extent, indicators and intervention strategies of soil degradation in the area as well as the resultant effect on food security within the area of study. Paper based questionnaire was the mainly considered ideal format and the closed-ended questions were asked considering the characteristics of the respondents as well as the need for large amount of data.

3.6.2 Key Informant Interview (KII)

Kothari (2004) views interview method in terms of how it is being administered by maintaining that it involves interviewer-interviewee engagements based on oral-verbal presentations characterized by instant feedback. Just like questionnaire, while it relies on the use of structured questions the set up on how it is administered is what differ such that the researcher has a chance to interact with the respondent on face to face basis (Mulusa, 1988 and Amin, 2003). In a research study whose main data collection tool is questionnaire, especially for Key Informant Interview (KII), it is always useful as a supplementary and follow-up method (Amin, 2003 and Kothari, 2009). Therefore this emphasizes its application in geographical studies as inevitable. The researcher used it to interview five key informants including; one Deputy County Director of Agriculture, one Sub- County Director of Agriculture, two field agricultural officers, and one officers from NEMA, Rachuonyo Sub-County branch. The interview questions focused on establishing the level of food security, investigating dominant indicators of soil degradation, main human practices that increases the risk of soil degradation as well as applicable strategies for soil management in the area of study. The appendix (iii) indicates matrix of sampled questionnaire and the question guide for Key Informant Interview as well as the respective associated variables.

3.6.3 Focus group discussion

The use of Focus Group Discussions (FGDs) technique is basically applied in the formal or non-formal design of conversation with an aim of obtaining insight of the research problem (Nyumba *et al*, 2018). In all these cases, FGDs, as qualitative approach in data collection, are usually used to enlarge the understanding of the researcher and equip him/her to gain a well-informed background of social issues being researched about.

Hence, it was necessary to use FGDs to particularly collect data about the residents' views on the extent of soil degradation and how human practices relate to soil health in the area of study. To achieve this, the researcher purposively used four groups, each from the four wards in the area within which the study was conducted. Further, the four groups were clustered as FGD_1 (Kendu Bay ward) FGD_2 (Kanyaluo ward), FGD_3 (Kibiri ward), and lastly FGD_4 (West Karachuonyo ward). Every group consisted of between six to ten adult residents considering mixed gender who were selected conveniently. This group size was considered to be appropriate in strict adherence to the Kenya's Ministry of Health Covid-19 protocols which was in effect during the period of data collection. The members of the groups were identified depending on their readiness, availability and willingness to participate in the discussion.

3.6.4 Field observation

Soil degradation has conspicuous observable indicators both at the lower, middle and higher elevations along the steep landscape (LADA, 2016). In relation to the area of study therefore, the focus of this method was to use generated observation schedule together with photographs to collect data on observable imprints and indicators of soil degradation. These could include exposed plant roots, bare and exposed upper slopes, accumulation of soils along the infrastructure such as roads, bending of trees, electric and telegraph poles, shallow and deep soil cuts as well as formation of gullies. Anthropogenic activities such as stone mining, and sand harvesting were observed. Further, observation was also focused on indicators of food insecurity including high food prices and low living conditions. Possible control measures against soil degradation in the area of study were also included in the schedule. The soil degradation intervention strategies such as organic farming, planting of vegetation, mulching practices, agroforestry, and mixed farming were also investigated through observation. Four identification details such as the ward, location, sub-location and date of observation that the researcher believed to be important were also included in the observation schedule. The table in Appendix I therefore, gives the summary of variables that were included in the observation schedule. It was marked accordingly as whether the variables were 'observed' or 'not observed' and remarks concerning its level indicated. In addition to this, photograph was also used to capture the images of the variables observed in the field.

3.6.5 Documents analysis

Analysis of documents (desk review) involves systematic procedures for reviewing and evaluating both printed and electronic documents (Bowen, 2009). It was therefore useful as one of the most important data collection tools in this research. Newspaper reports, cartographic maps, televised reports, charts, books, brochures, research journals, and photo albums were referred and used as documentary sources of information on soil degradation, food security and soil conservation measures in relation to the study area.

3.7 Data Processing, Analysis and Presentation

Data processing was conducted by editing the collected data to eliminate any errors. Coding was done with an aim of assigning numerical values to the collected field data. In addition, the researcher classified related and similar attributes together to aid in data analysis. According to Kothari (2004 & 2009), data editing, classification and coding are some of the key paths to processing field data.

Data analysis in this study involved the use of both descriptive and inferential approaches to statistical data analysis. Descriptive statistical analysis involved calculation of percentages, standard deviations, and variances of data on demographic characteristics of the respondents, human practices that are perceived to threaten soil quality in the four study wards as well as soil conservation measures. Data from questionnaire were analyzed using Statistical Packages for the Social Sciences (SPSS), version 25.0. For the second research objective, the data collected were subjected to significant tests using Binary Logistic Model. Korpi & Clark (2017) agree that a Binary Logistic Regression is a statistical method, used to predict the chances that an event falls into either one of two categories of a binary dependent variable based on one or more independent variables.

Omay (2010) maintains that Binary Logistic is suitable for establishing the impact of multiple independent variables which are presented simultaneously to predict membership of one or another of the two dependent variable categories. To successfully perform the binary logistic analysis in SPSS, the expected outcome, depicting success is represented by one (1) while the outcome depicting failure is coded zero (0) and the results of the analysis are in form of an odd ratio (Hayder *et al*, 2016). The conditions for performing binary logistic model according to Abdulqadar (2017) include; the independent variables need not to be in interval or normally distributed or linearly related or of equal variance within each group. The error terms, the residual, also do not need to be normally distributed. With logistic, the dependent variable must be dichotomous that is, two categories which must be mutually exclusive and exhaustive. This implies that a case must be a member of one of the groups or categories. These conditions were similar to the characteristics of data in this study thus its relevance for application. Therefore, the model was used to test the relationship between anthropogenic soil degradation practices and food security at 95% confidence level. The mathematical representation of the model is illustrated as follows;

$$\frac{P}{1-P}(X^*) = B_0 + B_1s_1 + B_2sn_2 + B_3t^hc_1 + B_4lr_i + B_5b^tc + B_6m_1 + B_7m^c$$

This model describes the probability of an event occurring as a function of *X* variables in such a manner that, $\frac{P}{1-P}(X^*)$ is the predicted variable, food security situation, which is dichotomous in nature. In relation to Hayder *et al* (2010) that the expected outcome in Binary Logistic Analysis is coded '1' while failure is coded '0', therefore accordingly, for the purpose of this study, the dependent variable , that is food security situation, was coded '1' to imply 'no food security' or '0' to imply 'there is food security.' The predictor variables are the perceived human-based soil degradation practices denoted as $s_1 + sn_2 + t^hc_1 + lr_i + b^tc + m_1 + m^c$ used to predict $\frac{P}{1-P}(X^*)$, that is, the probability that they affect food security situation with respect to regression coefficient $B_0+B_1+B_2+B_3\ldots+B_7$.

s_1 = intensive sand harvesting

sn_2= intensive stone mining

t^hc_1= tractor cultivation (convectional tillage).

lr_i = intensive livestock rearing

b^tc = bush and tree clearing

m_1= intensive hill slope settlement and cultivation

m^c = maize and sorghum cultivation.

Respondents were first asked to either agree or disagree whether soil degradation was common in their area of residence. They were further asked to indicate whether the perceived human-based practices were affecting soil quality in their area of residence. To gather data on the extent of the effect, they were asked to indicate the level at which human practice affect soil quality in their area of residence while to establish the effect of perceived human based soil degradation practices on food security they were asked to indicate the level of crop yield in relation to each practice. To organize these observations for analysis, the responses were dichotomized such that the observations such as ‘very low’ and ‘low’, coded as ‘0’ were classified as having no effect on the level crop yield while ‘average’, ‘high’ and ‘very high’, coded as ‘1’ were perceived as having effect on crop yield hence causing food insecurity in the area as summarized in table 3.2. Lastly, the analyzed data, both qualitative and quantitative data, were presented by use of charts, drawing tables as well as use of graphs.

Table 3.2: Summary of coded variables

Variables	Codes	Responses	Expected Signs
HHs food security situation	1	No food security	
	0	There is food security	
Trees and bush clearing	1	Yes	_
	0	No	+
Stone mining	1	Yes	_
	0	No	+
Sand harvesting	1	Yes	_
	0	No	+
Livestock rearing	1	Yes	_
	0	No	+
Continuous cultivation of maize and sorghum (monoculture).	1	Yes	_
	0	No	+
Tractor cultivation (conventional farming)	1	Yes	_
	0	No	+

Hill slope settlement and cultivation	1	Yes	_
	0	No	+

Key + Positive influence on food security _ Negative influence on food security
Source: Author (2022)

3.8. Pilot study

The pre-test was conducted during the first two weeks of the month of February, the year 2022. The pilot study was done at Wang'chieng' ward and Central ward, which are the neighbouring wards to the sampled four wards within the area of study. The researcher purposively distributed 20 research questionnaires to the farm families along the roads, traversing the area, also determined purposively. Pilot study helped the researcher to determine the reliability and validity of the research instruments. Proper modification was done on the document after the pilot study towards refining the tools in readiness for the actual field work.

3.9 Validity and reliability of research instruments

The results of the pilot study were used to test for the validity and reliability of the research tools. This is based on the view that developing a valid and reliable instrument requires several piloting together with testing which demand a lot of resource (Kubai, 2019).

3.9.1 Validity of the instrument

According to Carmine & Zeller (1979), validity is the extent to which a research tool, with precious exactness, measures what it intends to measure. This implies that validity explains how well an instrument measures what it intended to measure. This is the basis of content and predictive validity. While content validity indicates the extent to which a research tool precisely measure the variables under investigation, survey is predictively valid if the test properly predicts what it is supposed to measure accurately (Tojib & Sugianto, 2006). Further, Kubai (2019) suggests that it can also entail scores from the predictor measure are taken first and then the criterion data is collected later. To achieve these, with the help of the supervisors, the researcher was guided and advised accordingly to ensure relevance of the questionnaire to the study.

3.9.2 Reliability of research instrument

Majority of scholars with research interest on measurement and evaluation including Taherdoost (2016), view reliability as the degree to which an instrument yields consistent results. The main focus is to determine whether or not a research tool is able to yield the same answer through multiple test approaches (Elsayed, 2012). Therefore, to establish the reliability of the questionnaire as the main research tool for this study, the test and re-test method was applied. Accordingly, Kubai (2019) suggests that a test and re-test measures the correlation between scores from one successful administration of an instrument to another, usually within an interval between 2 to 3 weeks to an extent that no any level of treatment occurs between the time-interval of its administration.

Guided by this principle, then, the administration of the tools was carried out on two occasions within a period of two weeks with household heads from Wang'chieng and Central Karachuonyo wards found within the area of study. Reliability was established using Pearson Product Moment given that it is ideal for showing the strength and direction of association between the variables (Chee, 2015). Therefore, the Pearson correlation was used to test for the reliability of the questionnaire questions. It examined the cause-effect relationship between the perceptions of the area residents mainly farm families on the effect of human based soil degradation practices and food security. The findings showed that the mean for human based practices perceived to be causing soil degradation was 65% (S.D 0.489) while food situation was 75% (S.D 0.444). The relationship result (appendix v) shows that the direction of association was positive, and the level of relationship was statistically significant ($r = 0.545$ and $P < 0.013$). According to Obilor & Amadi (2018), the reliability result of more than 0.5 shows a reliable level of association between the variables. Therefore, the researcher was able to proceed with the study.

3.10 Research procedure

This study involved three successive stages. The first stage involved acquisition of research permit which sought for research authorization from the office of Deputy Vice Chancellor for Academic, Research and Extension of Moi University. Thereafter, the researcher proceeded to apply for the permit from the National Commission for Science and Technology (NACOSTI) and lastly sought for research permission from Homa Bay County Director of Education. The second stage involved conducting the pre-visit to the study area, a period during which the pilot study was done. Having successfully gone through the first two stages, the researcher proceeded to the third and the final stage of actual data collection. The letters of authorization were presented to local authorities where applicable.

3.11 Ethical consideration

According to Akaranga *et al* (2016), the purpose of research ethics is premised in the need to use human beings to conduct studies especially those in the field of biomedical research. Therefore, given that most of the researches touches on human social life (Mugenda, 2011), research ethics are rules and guidelines which are well-established with vivid clarity to defines the conducts or what is expected of researchers (Frankena, 2001) with an aim of protecting the dignity of their subjects and ensure that the information researched is well published (Ongong'a *et al*, 2013).

In light of these rules and guidelines, the researcher informed the respondents about the purpose of the research. Names of the respondents were not included in the questionnaires form. After the focus group discussions, the researcher took the photograph with only respondents who were willing and have participated in the discussion. During the interview sessions, the respondents were informed about the purpose of conducting the interview for this study. Only respondents who agreed were interviewed. Observations collected were used only to the interest and benefits of this study.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter contains data analysis, presentation, interpretation and discussion of the study findings.

4.2 Background information of the households and Key Informants

The study captured seven background characteristics of the household members based on gender, age, length of stay, employment status, and family size, level of monthly income and education level. The demographic and socio-economic information of the key informant included gender, age, and the years of stay as well as level of education. The demographic and socio-economic information were considered as key to understanding the variation in responses among the respondents.

4.2.1 Characteristics of respondents at household level

The study sought to present the characteristics of the individuals who were contacted as a unit of analysis of this study. In view of the above, the findings of this study with regards to gender of the respondents, show that the male were (50.2%) while the female were (49.8%) which is an indication of relatively equal gender representation.

On the other hand, the findings (Figure 4.1) on the age of the household head revealed that the majority 54.0% of the respondents were between 40 - 79 years while only 1.2% of them were above 79 years. Furthermore, the findings show that only 0.3% respondent was 20 years while 12.5% and 32.0% were between 21 - 30 years and 31 - 40 years respectively. Because understanding of the gravity of the level of soil degradation in an area needs individuals taking agricultural decisions (Ocelli *et al*, (2021), the younger age cohorts may lack requisite understanding of this phenomenon given that their lives are more urban where there is an alternative livelihood apart from agriculture. Therefore, the age of the respondent was considered an important aspect when it comes to the need to interrogate the understanding of the households about the extent of soil degradation in the area of study. This implied that the more the age of the respondents the more they were likely to precisely indicate the specific anthropogenic practices causing soil degradation in the area due to their rich experience they have gathered from farming in the area. Having this in mind, it was then considered that the respondents with below 20 years had relatively low understanding about the occurrence of soil degradation and their potential cause in their areas of residence while those above 20 years had a better understanding of the subject matter.

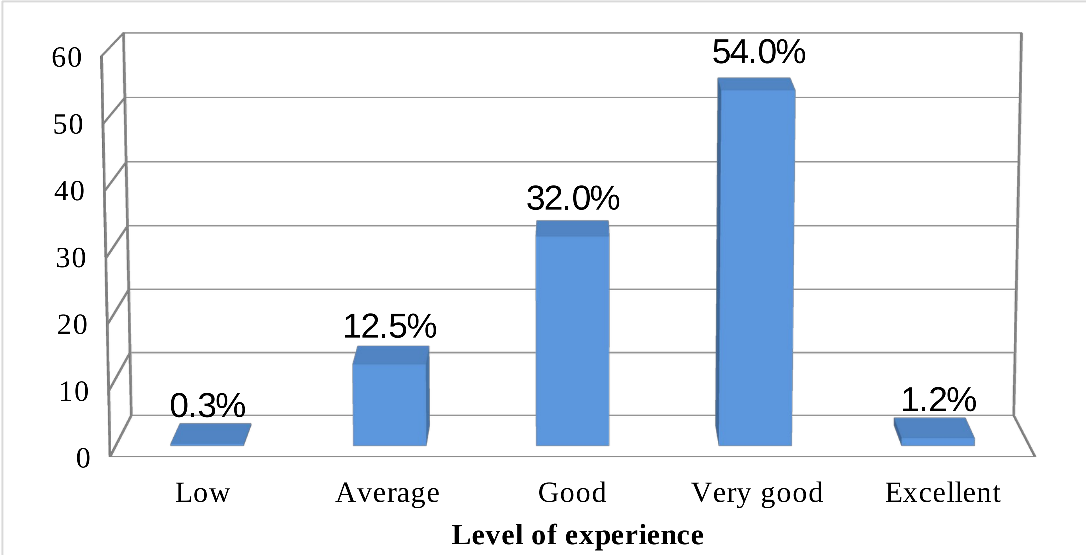

Figure 4.1: *Age of the respondents*

Source: *Author (2022)*

The results (Table 4.1) on the length of time the respondents have stayed in the area reveals that about 5.9% have stayed in the area for less than five years, while 12.1% have stayed between 5 to 15 years, 29.8% have stayed between 16 -25, and the remaining 14.5% have stayed between 26 - 35 years. Moreover, the majority 37.4% reported that they have stayed in the area for a period of between 36 - 78 years, while only 0.3% reported that they have stayed in the area for more than 78 years. In this study, it was considered that along with the age, the length of time the respondents had stayed in the area was critical in providing requisite information about the extent of soil degradation, the level of effect of human-based activities on soil degradation and their impact on food security in the area of study. Therefore, the longer the length of stay, the more the ability of the respondents to provide accurate and relevant observations about the subject matter. In this regard, the respondents with less than five years stay were perceived to have the lowest ability while above 78 years had the highest ability to indicate how different anthropogenic activities affect soil health condition in the area.

Table 4.1: The length of time the households have stayed in the area.

Length of years of stay	**Frequency (n=289)**	**Percentage (%)**	**Cumulative (%)**
<5	17	5.9	5.9
5-15	35	12.1	18.0
16-25	86	29.8	47.8
26-35	42	14.5	62.3
36-78	108	37.4	99.7
>78	1	0.3	100.0

Source: Author (2022)

Regarding the respondents’ education level, the results (Figure 4.2) show that the majority 50.2% of the respondents had never gone beyond primary level of education, while 32.5% reached secondary level of education, 17.3% reported to have advanced their education status beyond secondary level. It was important to ascertain the level of education of the household because essentially, education provides learning opportunities much needed for environmental management and conservation. The higher the level of education of the respondents the more they are likely to take sustainable decisions concerning the utilization of environmental resources.

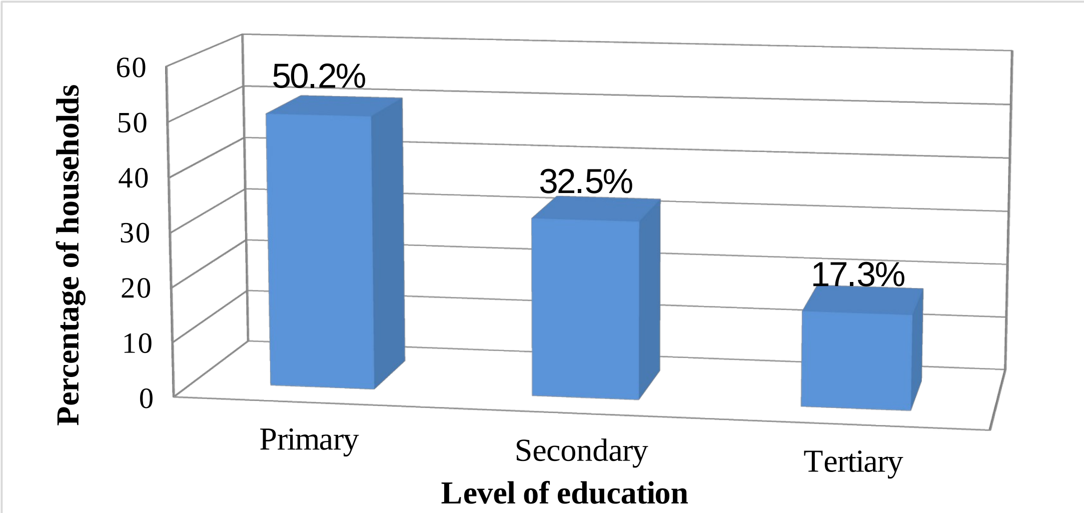

Figure 4.2: *Level of education of the households*

Source: *Author (2022)*

The study also sought to establish the employment status of the respondents regardless whether employed in public or private sectors. Salaried employment opportunities are alternative sources of income that in addition to other associated benefits, can be partly invested in soil management and conservation practices which according to Bagarello (2017), require capital investment. The findings which indicated that the majority, 85.1% , were not employed against the employed 14.9% therefore means that majority of the households while on one side they are less likely to invest in soil management and conservation strategies, on the other side, they are more likely to embark on intensive exploitation of environmental, including soil, resources to solve their immediate economic pressure even at the face of the waiting dander of soil health reduction with its long term impact on food insecurity.

Furthermore, the results (Table 4.2) on the family sizes of the respondents show that the majority 42.9% and 39.1% had between 3 - 6 members, and 7 - 10 members respectively.

In addition, the results further revealed that about 9.7% had between 11 – 13 household members, while 6.6% had between 14 - 24 members, 0.3% reported to have more than 25 members, and only 1.4% had less than three family members.

Table 4.2: Family size of the households

Family size	Frequency (n=289)	%	Cumulative %
<3	4	1.4	1.4
3-6	113	39.1	40.5
7-10	124	42.9	83.4
11-13	28	9.7	93.1
14-24	19	6.6	99.7
>25	1	0.3	100.0

Source: Author (2022)

Moreover, the study sought to determine the level of income of the respondents, on a monthly basis and the results (Table 4.3) show that the majority 77.2% of the respondents reported their monthly income to be within the bracket of Ksh. 201 to 10,000 and only 0.3% respondents had a monthly income of below Ksh. 201. Additionally, about 17.3% respondents had a monthly income of between Ksh. 10,001 to Ksh. 25,000, while 3.1% had a monthly income of between Ksh. 25,001 to Ksh. 40,000, 1.4% had a monthly income of between Ksh. 40,001 to Ksh. 49,999, and only 0.7% respondents had monthly income of above Ksh. 50,000.

Table 4.3: Level of monthly income of the households

Monthly income (Ksh.)	Frequency	%	Cumulative %

< 201	1	0.3	0.3
201- 10,000	223	77.2	77.5
10,000-25,000	50	17.3	94.8
25,001-40,000	9	3.1	97.9
40,001- 49,999	4	1.4	99.3
>49,999	2	0.7	100.0
n	**289**	**100.0**	

Source: Author (2022)

4.2.2 Summary Statistics of the Key Informants

Regarding the Key Informants, the results (Table 4.4) show that out of the five interviewed respondents, 3 (60%) of them were male and 2 (40%) female. Furthermore, the two Informants were 37 years old while the rest were 48, 56 and 57 years. The lowest year of stay was 5 years while the highest was 12 years. The education level for all the Key Informants was tertiary level. The length of stay and education level meant that the Key Informants had worked in the area long enough and highly experienced to provide valid responses as far as soil degradation is concern as well as its effects on the area residents' welfare such as food in/security.

Table 4.4: Characteristics of Key Informants

Characteristics	**Responses**	**Frequency (n=5)**	**%tage**
Gender	Female	2	40.0
	Male	3	60.0
Age (Years)	37	2	40.0

	48	1	20.0
	56	1	20.0
	59	1	20.0
No. of years of work in the area (Years)	5	1	20.0
	6	1	20.0
	9	1	20.0
	10	1	20.0
	12	1	20.0
Education level	Tertiary	5	100.0

Source: Author (2022)

4.3. Anthropogenic practices causing soil degradation in Rachuonyo North Sub-County

The study sought to investigate the main anthropogenic activities in the area of study while examining their contribution on soil degradation. The respondents were first asked to indicate whether soil degradation occurs in their area of residents and if it occurs they were subsequently asked whether human practices could be the main cause of soil degradation. The results (Table 4.5) show that the majority 98.3% of the interviewed residents had a view that soil degradation is common in the area while only 1.7% had a contrary view. Respondents who indicated that soil degradation is ‘very low’ and ‘low’ in their responses were considered to have said there is no soil degradation while those who indicated ‘average’, ‘high’ and ‘very high’ were considered to have said ‘there is soil degradation in the area of study.

Table 4.5: Perception on the occurrence of soil degradation in their area of residents

Characteristic	Responses	Frequency (n=289)	%tage	Cumulative %
Level of soil degradation	There is no soil degradation	5	1.7	1.7
	There is soil degradation	284	98.3	100.0

Source: Author (2022)

Further, the results **(**Table 4.6) shows that the majority 91.7% of the respondents, pointed out that human practices cause soil degradation in the area, only 2.4% disagreed while 5.9% were undecided. Therefore, these findings show that soil degradation is common in the area of study and it is significantly caused by anthropogenic practices.

Table 4.6: Perception on anthropogenic activities as the cause of soil degradation in their area of residents

Characteristic	Responses	Frequency(n=289)	% tage	Cumulative %
Human practices	Disagree	7	2.4	2.4
	Agree	265	91.7	94.1

Undecided	17	5.9	100.0

Source: Author (2022)

In comparison with respondents' demographic data (Table 4.7), majority between 21-30 years 94.4%, 31-40 years 97.8, 41-79 years 99.4% and above 79 years 100% of the interviewed residents had a view that there is soil degradation in their areas of residence. Further, concerning the length of time the respondent has stayed in the area, majority of the respondents who had stayed in the area between 6-15 years 100%, 16-25 years 97.7%, 26-35 years 97.6%, 36-78 years 98.1% and above 79 years (100%) also had a view that soil degradation is common in their areas of residence. Regarding the level of education attained, majority of the respondents 98.9%, 98.6% and 96.0% with secondary, primary and tertiary as their level of education respectively had a view that soil degradation is common while on the other hand results concerning the employment status showed that 100% and 98.0% of the employed and unemployed interviewed residents respectively indicated that soil degradation is a common phenomenon in their area of residence. This implies that regardless of age, length of stay, level of education and employment status of the respondents there was a common view that soil degradation is evident in the area of study.

Table 4.7: Soil degradation in relation to demographic data of the respondents

Characteristics	**Frequencies (n=289)**	**There is no soil degradation**	**There is soli degradation**

Age(Years)	20	N=1	0.0%	100.0%
	21-30	N=36	5.6%	94.4%
	31-40	N=92	2.2%	97.8%
	41-79	N=156	0.6%	99.4%
	Above 79	N=4	0.0%	100.0%
Length of stay	< 5	N=17	0.0%	100.0%
	6-15	N=35	0.0%	100.0%
	16-25	N=86	2.3%	97.7%
	26-35	N=42	2.4%	97.6%
	36-78	N=108	1.9%	98.1%
	Above 78	N=1	0.0%	100.0%
Employment status	Employed	N=43	0.0%	100.0%
	Unemployed	N=246	2.0%	98.0%
Level of education attained	Primary	N=145	1.4%	98.6%
	Secondary	N=94	1.1%	98.9%
	Tertiary	N=50	4.0%	96.0%

Source: Author 2022

Demographic data such as age, length of stay, level of education, employment status, and gender were considered as key determinants on whether the respondents were to agree or otherwise disagree that human practices are the cause of soil degradation in the area of study. The study findings (Table 4.8) show that in relation to respondents' age, majority, between 31-40 years 89.1%, 41-79 years 95.5% and above 79 years 100% had a view that human-based practices are the cause of soil degradation in their areas of residence. Concerning length of time the respondent has stayed in the area, majority of the respondents between 6-15 years 88.6% agreed as compared to only 11.4% who disagreed, between 16-25 years 89.5% agreed as opposed to only 10.5% who had a contrary view while between 26-35 years 95.2% agreed as compared to 4.8% who disagreed.

Majority between 36-78 years 94.4% agreed while just 5.6% disagreed and lastly all the respondents above 79 years 100% length of stay indicated that human activities are the main cause of soil degradation in their areas of residence. Regarding the level of education attained, majority of the respondents 92.6%, 92.0% and 91.0% with secondary, tertiary and primary levels of education respectively had a view that human activities cause soil degradation while results concerning the employment status showed that 93.0% and 91.5% of the employed and unemployed respondents respectively agreed while conversely 7.0% and 8.5% of the employed and unemployed respondents respectively had contrary view. Moreover, regarding the gender of the respondents, majority 91.0% and 92.4% female and male respectively had a view that human practices have more influence on soil degradation in the area. This also implies that regardless of age, length of stay, level of education, employment status as well as gender of the respondents there was a common view that soil degradation is evidently caused by human-based practices in the area of study.

Table 4.8: Households' demographic data in relation to effects of anthropogenic practices on soil degradation

Characteristics		Frequencies (n=289)	No soil degradation	There is soil degradation
Age(Years)	20	N=1	100.0%	0.0%
	21-30	N=36	16.7%	83.3%
	31-40	N=92	10.9%	89.1%
	41-79	N=156	4.5%	95.5%
	Above 79	N=4	0.0%	100.0%
Length of stay (Years)	Up to 5	N=17	17.6%	82.4%
	6-15	N=35	11.4%	88.6%
	16-25	N=86	10.5%	89.5%
	26-35	N=42	4.8%	95.2%
	36-78	N=108	5.6%	94.4%
	> 79	N=1	0.0%	100.0%
Employment status	Employed	N=43	7.0%	93.0%
	Not employed	N=246	8.5%	91.5%
Level of education	Primary	N=145	9.0%	91.0%
	Secondary	N=94	7.4%	92.6%
	Tertiary	N=50	8.0%	92.0%
Gender	Female	N=144	9.0%	91.0%
	Male	N=145	7.6%	92.4%

Source: Author 2022

4.3.1 Bush clearing and tree cutting

The observations about the extent of forest and bush clearing showed that clearing vegetation is a common practice in all wards of Rachuonyo North Sub-County. However, the result (Figure 4.3) shows that the level was reportedly varying from one ward to another. For instance, West Karachuonyo ward had the highest record of 88.8% respondents reporting cases of tree cutting with only 11.2% respondents disagreeing. This was followed by Kibiri ward with 86.6% agreeing against 13.4% respondents with contrary view. Kanyaluo ward had 84.1% who agreed as compared to 15.7% who disagreed. Moreover, in Kendu Bay, while majority of the interviewed residents 72.9% agreed that tree cutting is common in their area of residence, 27.1% of them disagreed.

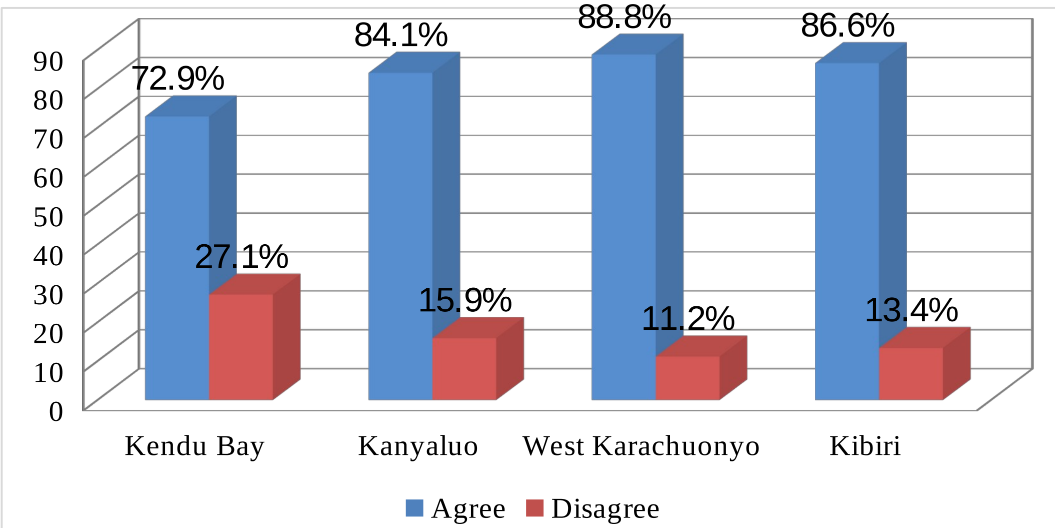

Figure 4.3: *Extent of bush clearing and tree cutting in Rachuonyo North*

Source: *Author (2022)*

Accordingly, this study also sought to assess the cases of tree cutting in the area and the results (Plate 4.1) indicated a wide spread tree logging in most parts of the area of study. During Focused Group Discussion in Kanyaluo Ward (FGD_2), one of the participants said that;

"Trees are largely cut for commercial consumption such as charcoal burning, construction, and firewood".

Plate 4.1. *Tree cutting for firewood in Kanyaluo ward in the study area*
Source: *Author (2022)*

When the respondents were asked whether the level of bush clearing and tree cutting has affected soil health in their areas of residence, the findings (Figure 4.4) show that in West Karachuonyo ward 89.9% agreed while 10.1% disagreed. The results from Kibiri ward revealed that 86.6% agreed against 13.4% who disagreed that level of deforestation has affected soil health in their areas of residence. Concerning Kanyaluo ward, the results show that 84.1% of the respondents agreed against 15.9% who disagreed while in Kendu Bay Ward, 78.6% agreed as opposed to 21.4% who disagreed. In overall, while only 15.2% had contrary view, the majority 84.8% of the respondents across the four wards reportedly had the view that bush clearing and tree cutting is common in the area of study. This then indicates that though the practice is evident in all wards in the area of study, West Karachuonyo had reported the highest cases of tree cutting and bush clearing affecting soil quality while Kendu Bay ward registered the lowest cases of the same. However, in average, the effect of tree cutting and bush clearing on soil health remained to be high, (84.8%), across the wards and this shows that it's one of the major causes of soil degradation in the study area.

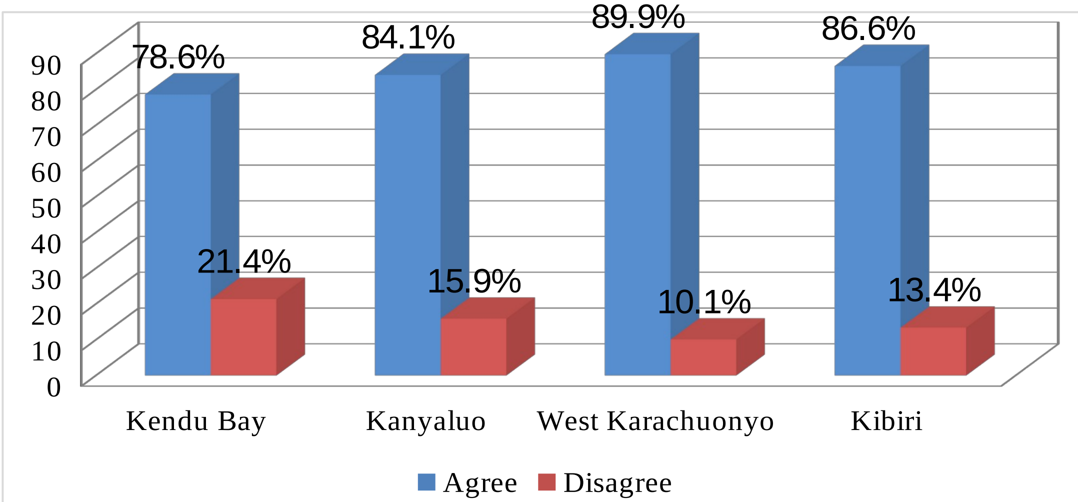

Figure 4.4: *Effect of bush clearing and tree cutting on soil degradation in the study area*

Source: *Author (2022)*

4.3.2 Monoculture and continuous cropping

Study findings (Figure 4.5) showed that there is continuous cultivation of maize and sorghum in the area of study to an extent that in Kanyaluo ward 99.9% of the interviewed respondents agreed. In West Karachuonyo ward, 98.9% respondents agreed while only 1.1% disagreed. Regarding Kendu Bay ward, majority of the respondents, 98.6% agreed that they are continuously cultivating either maize or sorghum while only 0.3% disagreed and lastly in Kibiri ward, majority of the respondents 97.0% also had the same opinion against 3.0% who disagreed. Generally, these point out that the area experiences high cases of continuous cultivation as well as monocropping of the main food crops such as maize and sorghum.

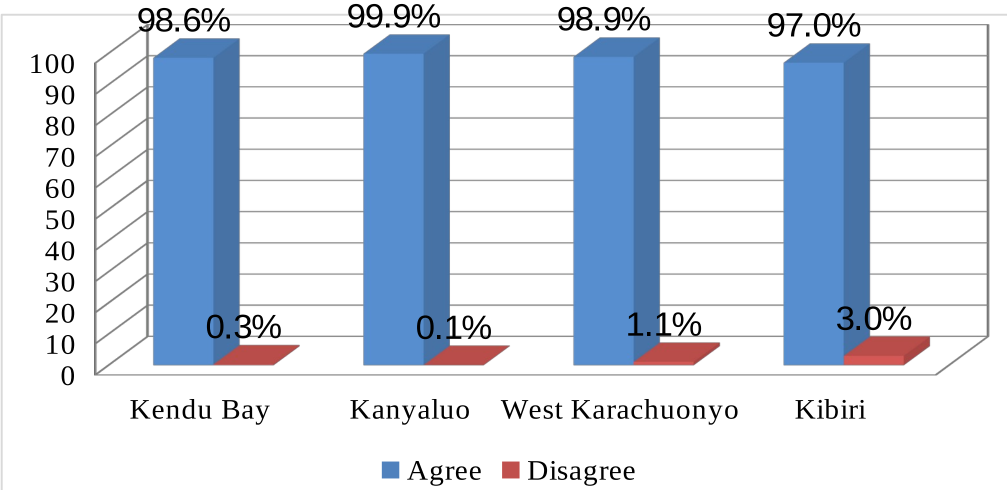

Figure 4.5: *The level of continuous cultivation of maize and sorghum in the study area*

Source: *Author (2022)*

Moreover, during Focused Group Discussion in West Karachuonyo Ward (FGD_4), one of the participants had a view that;

> *"Continuous maize and sorghum cultivation is commonly practiced among the majority of the residents in all wards with only a few doing the crop rotation."*

Similarly, the interviewed Key Informant reported that;

> ‘‘ *Though the intensive maize and sorghum cultivation among the area residents is as a result of, physical conditions such as favourable climatic and soil conditions, the local residents prefer them first mainly because they are their main staple food and secondly due to increased human population hence there is increasing demand.*’’

Therefore, the nutrients of these soils in light of (Anelia *at al*, 2012; Killebrew & Wolff 2010) are at risk of depletion. All the interviewed Key Informants agreed that in case of over cultivation without or minimal rest period that can enable the soil regain its nutrients, the soil organic content becomes low hence it becomes first less productive and secondly more vulnerable to degradation processes. This explains why when the respondents were further asked to indicate whether monocropping and continuous cultivation of maize and sorghum has affected soil health in their areas of residence, the findings (Figure 4.6) show that in West Karachuonyo, 93.3% agreed as opposed to 6.7% who disagreed and while in Kibiri ward, 83.6% agreed against 16.4% who disagreed. In Kanyaluo ward, 77.1% respondents agreed against 22.9% who disagreed and finally with regard to Kendu Bay ward 61.4% agreed while 38.6% disagreed. While West Karachuonyo reported the highest effect of continuous and monocropping on soil health, nearly 10% higher than the findings in Kibiri ward, the results in both Kendu-Bay and Kanyaluo wards reported the lowest effect of this practice on soil health.

However, in average, the findings point out that majority of respondents, 82.0%, had the view that continuous cultivation of maize and sorghum has lowered soil quality in their area of residence and this points out that this practice is one among the causes of soil degradation in Rachuonyo North Sub-County.

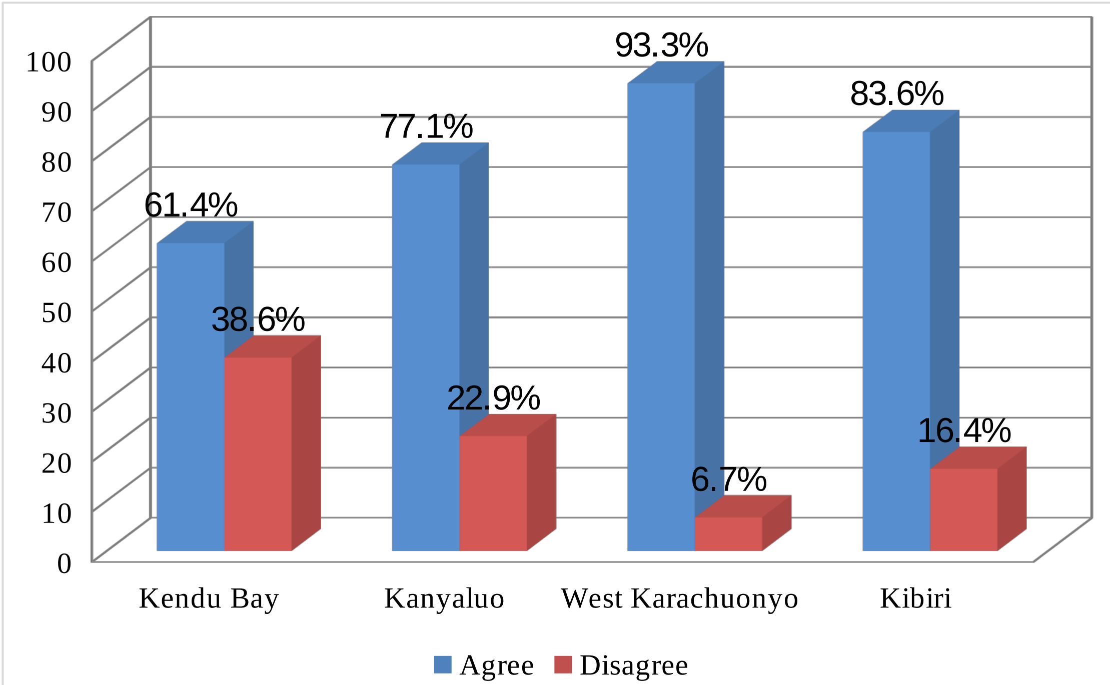

Figure 4.6: *Effect of continuous cultivation of maize and sorghum on soil quality in the study area*

Source*: Author (2022)*

4.3.3 Conventional tillage and methods of cultivation

Regarding this practice, the respondents were asked to indicate whether there is preference to the use of tractor cultivation among the area residents. The observations (Figure 4.7) show that Kibiri ward (98.5%), Kanyaluo ward (98.4%) and West Karachuonyo ward (94.4%) had the highest preference as compared to Kendu Bay where 81.4% had a similar view.

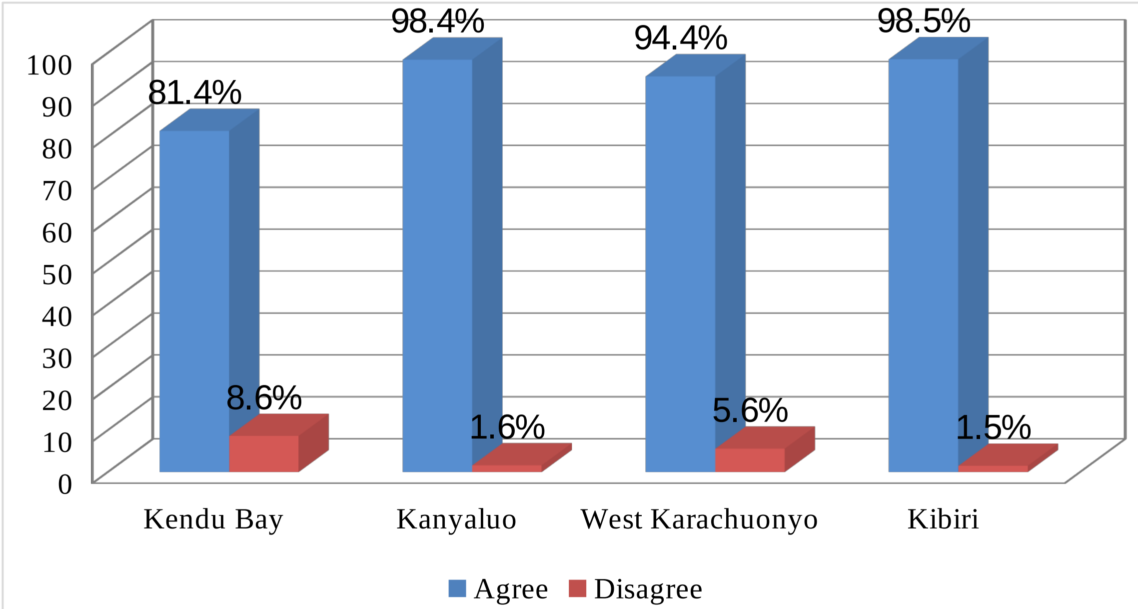

Figure 4.7: Level of tractor tillage in Rachuonyo North

Source: *Author (2022)*

When the respondents were further asked to indicate the level of effect of the methods of tractor tillage on the soil, the findings (Figure 4.8) show that; 52.9% agreed that it has lowered soil quality while 47.1% disagreed in Kendu Bay ward. In Kanyaluo ward, 95.2% had a view that tractor cultivation has reduced soil quality against 4.8% who disagreed. Similarly, 95.5% and 91.0% in West Karachuonyo and Kibiri wards respectively had the same view as compared to 4.5% and 9.0% in the same wards respectively who disagreed. These findings indicate that, on average, majority of the respondents 84.1% perceived tractor cultivation as largely contributing to soil quality reduction in the area of study.

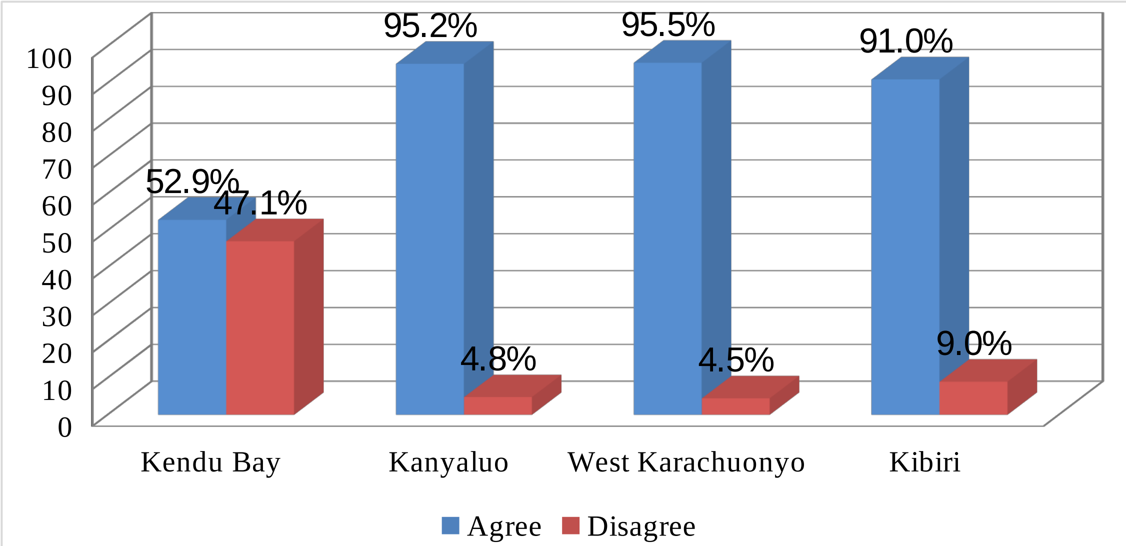

Figure 4.8: *Effect of tractor cultivation on soil quality in the study area*

Source: *Author (2022)*

Therefore, it means that majority of the residents in the area of study have embraced the use of tractor cultivation. While farm mechanization is contemporarily important to the much needed improved production to achieve socio-economic fulfillment, the methods of its practice are not sustainable if the objective of its application is not achieve. It is expected that when tractor tillage is used, there should be nearly or equivalent improvement in food production, as a mechanism to addressing the problem of food insecurity in Kenya and by large the world (Busari *et al*, 2015, Karuma *et al*, 2016, Wawire *et al*, 2018 & Mutonga *et al*, 2019). However, the findings of this study show that the use of tractor in cultivating farms in the study area is counter-productive as it lowers soil quality hence raising concerns about the sustainability of its practice.

Additionally, the findings of FGDs revealed that in Kibiri Ward (FGD_3) tractor cultivation is rapidly replacing the over-the-years standing hand and oxen cultivation methods in

Rachuonyo North Sub-County because first, it is based on pride and modern-day fashion that every farmer wishes to embrace tractor cultivation. One of the participants said that;

> *"I experience a heart of complete fulfillment to see a tractor roll soils upside and down in my own farms. It just makes me feel happy and not left behind if not different and peculiar among them."*

Secondly, the number of oxen for cultivation has decreased in the area because for many reasons but majorly deaths due to diseases. One of the Key Informant interviewed also maintained that;

> *"Most oxen in the area are facing out rapidly due to diseases and this leaves the local farmers with no alternative but to use tractors.''*

While in most of the KII sessions including (Plate 4.2) majority of the Key Informant suggested the need and accepted the wide spread use of tractor cultivation in the area, they regretted the knowledge behind its application and even its future prospect given that majority of the smallholder farmers don't have adequate knowledge with regard to tractor farming because most of them use it even in area which require an alternative and a more conservational tillage such as the use of oxen.

Plate 4.2. *A researcher (Center) together with the Rachuonyo North Sub-County Director of Agriculture (Left) and the Agricultural Ward Officer (Right) at the Sub County Headquarter after the interview sessions*
Source: *Author (2022)*

Field-based observations using photographs (Plate 4.3a) and (Plate 4.3b) indicate different farms which have been cultivated using tractors. However, the soils in these farms are geologically restricted such that first the top soil layer is very thin and secondly the farms are located on relatively steep slopes. Therefore, even when tractors cultivation is central to improving production (Ngetich, 2008), the methods and the knowledge behind its application are key to sustainable achievement of the farmers' intention of improving the yield in such a manner that if it's not monitored according to (Cornelis *et al*, 2013 & Busari *et al*, 2015) can be conventional in nature thus potential in reducing soil organic content as well as altering soil structure. This then implies that the methods of tractor cultivation in the area of study, as almost the only cheaper option for farming is questionable because it is exposing the soils to physical degradation processes including soil erosion due to increased surface run-offs in addition to interfering with their physical properties.

(a) (b)

Plate 4.3: *(a) Tractor tillage in Kendu Bay ward, and (b) Steep slopes cultivated using tractor at West Karachuonyo ward both in Rachuonyo North Sub-County.*
Source: *Author (2022)*

In relation to other farming methods**,** although groups' participants during FGDs maintained that farmers have not been using chemical fertilizers, one of the participant was having a feeling that with the advent of current advisories which are encouraging the use of inorganic fertilizers in the area some farmers have given it a trial. As a consequent of this trial, during Focused Group Discussion at Kendu Bay Ward (FGD_1) one of the participants noted that;

> **"***Personally, nowadays I don't accept the use of chemical fertilizer (locally called 'mbolea') given that when I first used it, the initial yield was high but now the yield is very low,***"**

Additionally, the finding at Kanyaluo ward (FGD_2) revealed that there is wide application of herbicides and insecticides in the area. This, according to one Key Informant, has encouraged the rapid and wide spread growth of a weed technically known as 'striga' but locally called '*kayongo*' or '*obwanda*' which has caused 'burning effect' to the soil hence advancing soil degradation (Plate 4.4).

Plate 4.4: Researcher with two participants in Kendu Bay Ward being helped to identify 'striga' weed.
Source: *Author (2022)*

Moreover, the results of FGD_2 show that cultivation across the contours, which is from top of the slope to the bottom, was also a common field practice in the area of study. With the aid of photographs taken, it was openly observable that majority of the local residents continue to plough along the slopes of elevated landscapes within the area of study (Plate 4.5a). Such practices leads to formation of easy water pathways (Moreno, *et al*, 2010) hence accelerating surface run-offs which causes a lot of top soils to be carried away thus stripping the soil its nutrients and formation of deep surface cuts as evidenced in plate 4.5b and this according to Abdallah,*et al* (2018) can eventually advance into the nearby farm lands.

(a) (b)

Plate 4.5. (a) *Illustration of along the slope cultivation and (b) illustration of progressing surface down-cutting due to rapid surface run-offs both in Kanyaluo ward, Rachuonyo North Sub-County.*

Source*: Author (2022)*

This therefore means that in addition to improper methods of tractor cultivation, other farming methods such as the use of chemical fertilizers in the area as opposed to organic manure as well as poor farming techniques including farming across the contours are common which consequently cause soil degradation.

4.3.4 Intensive settlement and cultivation on the steep hill slopes in the study area

Respondents were asked to indicate whether human practices particularly farming and settlement on the steep slopes was common in their areas of residence. The results (Figure 4.9) reveals that in Kanyaluo ward majority 87.3% agreed that there are intensive settlement and farming in areas of high elevation whereas only 12.7% disagreed while 84.3% agreed in West Karachuonyo ward contrary to only 15.7% who disagreed. Further, in Kibiri ward, 67.2% agreed while 32.8% disagreed. However, in Kendu-Bay ward only 48.6% had a view that human settlement and cultivation is high in sloping zones contrary to majority 51.4% who disagreed. These results reveal that human settlements and cultivations in areas of high elevation is highly common in Kanyaluo and West Karachuonyo wards while less common in Kibiri and Kendu Bay wards. In areas where these practices were reported, especially the slopes of Homa-hills in West Karachuonyo, the respondents had the view that these practices have lowered soil quality.

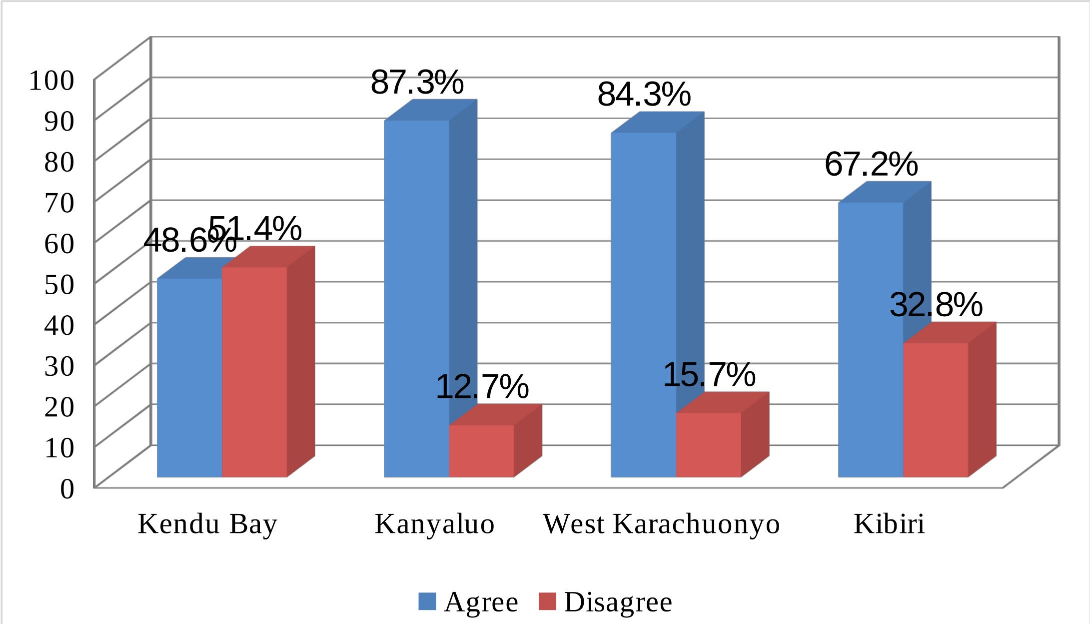

Figure 4.9: *Level of hill slope cultivation and settlement in the study area*

Source: *Author (2022)*

The results, figure 4.10 also shows that in an average, 79.1% of the respondents indicated that human settlement and cultivation on steep hill slopes reduces soil quality in the area of study against 20.9% who disagreed. These results relate to the findings of studies (Acharya *et al*, 2008; Killebrew & Wolff, 2010; Moreno *et al*, 2010; Zhang *et al*, 2015 & Abdallah,*et al*, 2018) who opine that soil degradation is intensified when intensive agriculture and settlements are magnified on the steep slopes.

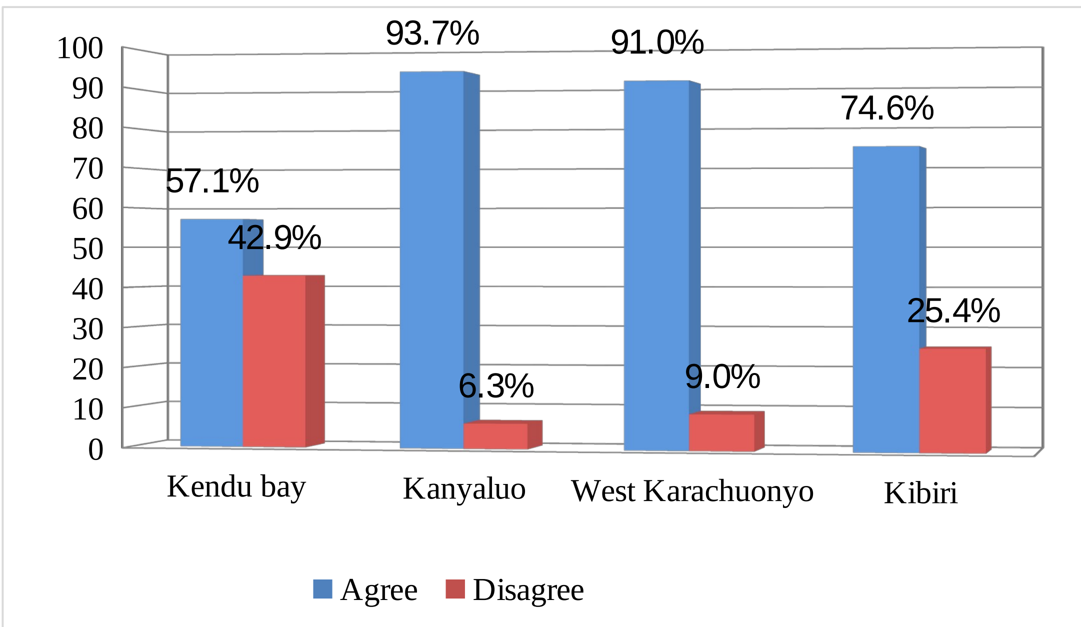

Figure 4.10: *Perception on effect of hill slope cultivation and settlement on soil quality*

Source: *Author (2022)*

Photographs taken during direct field observation for example in West Kachuonyo Ward (Plate 4.6) revealed that human activities especially farming were common on the steep slopes of elevated areas. Further, during Key Informant Interviews one of the participants affirmed that;

> **‘‘***There are more human practices particularly settlement and maize farming towards the top of the hill especially in West Karachuonyo where we have Homa hills which I believe has led to formation of deep gullies in the lower sections of the region due to rapid water movement*.**’’**

These views indicate that intensified cultivation and settlement which are reportedly common on some of the steep slopes in Rachuonyo North Sub-County, including the slopes of Homa Hills, have increased cases of soil degradation both at the top and lower sections of the slopes.

Plate 4.6: Cultivated section of steep slopes of Homa Hills in West Karachuonyo, Rachuonyo North

Source: *Author (2022)*

4.3.5 Intensive livestock husbandry

The respondents were asked to indicate the extent to which livestock farming could be affecting soil quality in their areas of residence. The observations (Figure 4.11) were such that majority of the respondents in West Karachuonyo ward 91.0% said that it was high as compared to 9.0% who had a contrary view. In Kendu Bay ward, 90% said that it was high while according to (10%) it was low. Additionally, in Kanyaluo ward those who responded as high were 82.5% against 17.5%) low while in Kibiri ward, 82.1% viewed it as high as opposed to 17.9% low. This point out that the effect of livestock farming is reportedly high in the four wards in the area of study though the effect is more in West Karachuonyo and Kendu Bay.

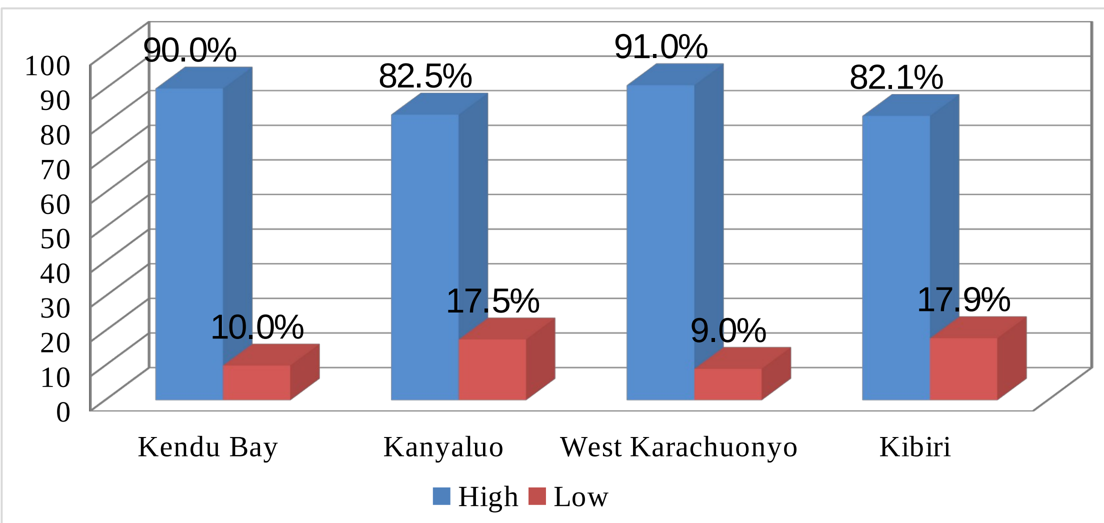

Figure 4.11: *Effect of livestock rearing on soil quality in the study area*

Source: *Author (2022)*

Further, during FGD_1 and FGD_3 participants had a view that smallhold livestock farming has affected soil health in their area of residence considering the manner in which it is being practiced including open grazing as well as overstocking. One of the participants said that;

> ''*While some people have large number of animals they are normally set free to graze anywhere which in my view affect our soils*.''

Considering that the poor methods of livestock rearing such as uncontrolled grazing, large number of livestock and more time spent grazing in one area decrease the rate of plant recovery, which may lead to loss of biodiversity and ultimately causing soil degradation (Salzman, 2004; Cummin, 2009; Lambin *et al*, 2009 & Weger *et al*, 2011), the methods of animal husbandry in the study area are also questionable because this study has established that they are exposing the soils to the processes of soil degradation.

4.3.6 Sand harvesting

The observations concerning the level of sand harvesting in Rachuonyo North (Figure 4.12) showed that in West Karachuonyo 92.1% of the respondents disagreed against 7.9% who agreed. In Kibiri ward, 77.6% disagreed against 22.4% who agreed. As compared to 58.7% who disagreed and 41.3% who agreed in Kanyaluo ward, 50% of the respondents agreed that sand mining is common while the same number disagreed in Kendu-Bay ward. Averagely majority of the respondents (65.3%) maintained that sand harvesting is not common in the agricultural lands within the area of study.

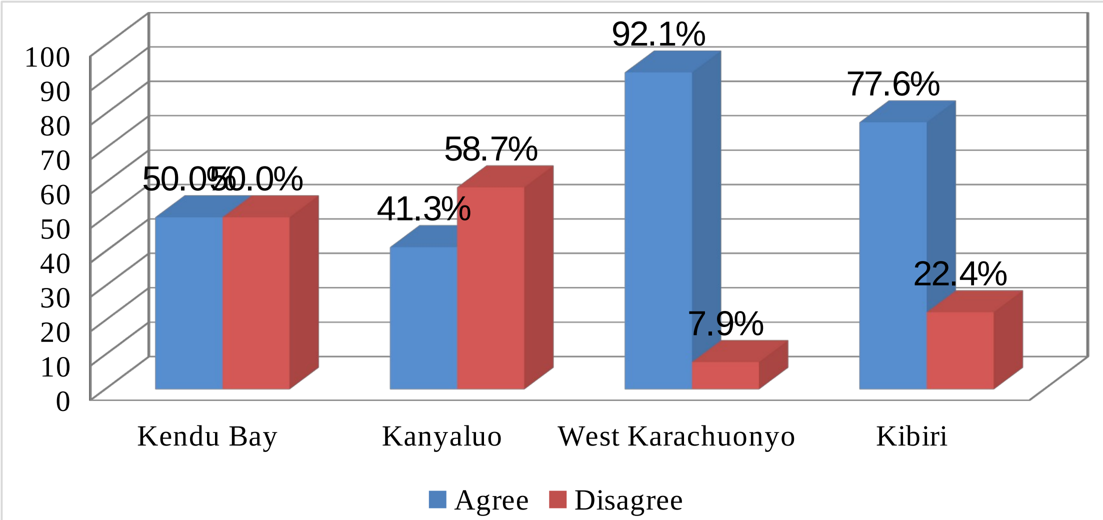

Figure 4.12: *Level of sand harvesting in Rachuonyo North*

Source: *Author (2022)*

Accordingly, when the respondents were further asked to indicate whether or not sand extraction in the area affects soil quality, the findings (Figure 4.13) shows that majority disagreed in Kanyaluo, West Karachuonyo and Kibiri wards while in Kendu Bay ward, more respondents, 54.3%, agreed as compared to 45.7% of the respondents who had contrary view.

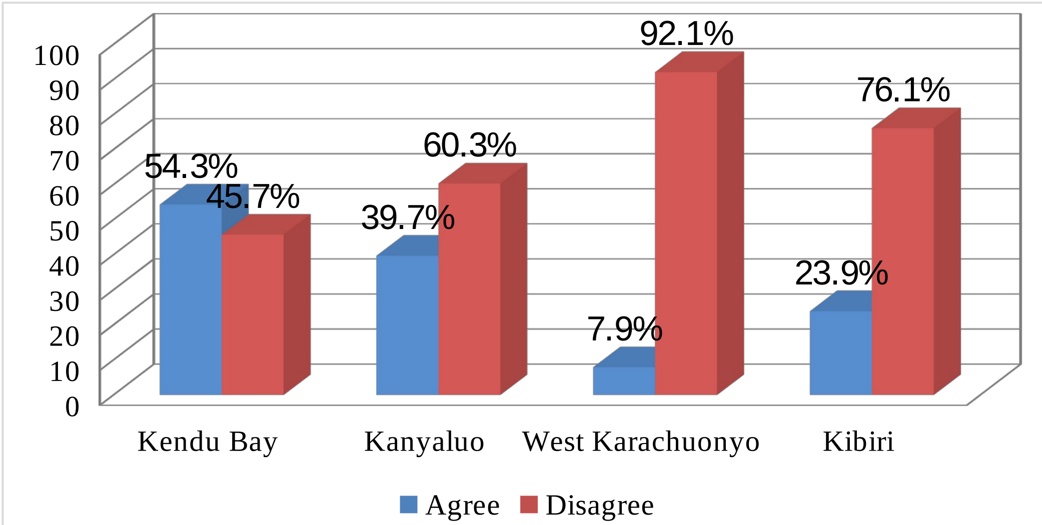

Figure 4.13: *Perception on the effect of sand harvesting on soil quality*

Source: *Author (2022)*

During FGD_2, FGD_3 and FGD_4 discussions, majority of the participants maintained that while sand harvesting was not common in the farming lands, the practice was reportedly common in the rivers, swamps as well as at the shores of Lake Victoria located within the study area. However, during FGD_1 one of the group participants whose view was supported by others reported that;

> "*Some people around this place are fond of harvesting sand from their own farms or along the roads traversing near those farms. These farms can be used for growing crops such as cassava among other food crops we depend on for survival. However, when sands have been extracted from these farms, it becomes very difficult to use them for growing crops again.*"

Additionally, one of the group participants also added that;

> *"In such farms where sands have been extracted continuously, water normally accumulate in the many shallow holes formed in those farms making them to be less agriculturally productive."*

Data collected through direct field observation (Plate 4.7) also reveal that most agricultural lands mainly in Kendu Bay and Kanyaluo particularly where the local residents have designated for sand harvesting and sand storage, have turned into derelicted lands. These lands according to (Mungai *et al*, 2000; Ashraf *et al*, 2011 & Mngeni *et al*, 2016) are less suitable for farming.

Plate 4.7: *Degraded soil due to sand harvesting in Kanyaluo ward*
Source: *Author (2022)*

Key Informants were further interviewed to gain more understanding concerning the effect of sand harvesting on soil quality in the study area. Some of them had a view that sand harvesting is highly common in the area particularly in Kendu Bay and Kanyaluo even as one of them emphasized that;

> ''*While some of the residents lease out their farms to private developers for commercial sand mining, some other households extract sand from their farm lands for selling. Consequently these farms are deprived soil nutrients hence they are less productive.*''

However, majority of the interviewed Key Informants maintained that this practice is not common in the agricultural lands in the area but rather rampant in beaches along the shores of Lake Victoria and in some rivers especially during the rainy seasons. Therefore, this practice is less likely to be associated with soil degradation in the area.

4.3.7 Stone mining

The observations in relation to quarrying in Rachuonyo North also revealed that stone mining is one of the major economic activities practiced in all wards in the area of study. Respondents were asked about the extent of stone mining in their areas of residence. The results (Table 4.9) shows that in Kanyaluo ward majority of the interviewed respondents 84.1% indicated that it was high while only 15.9% of them reported it as low. Moreover, while majority 79.8% of the respondents reported it as high whereas 20.2% of them reported it as low in West Karachuonyo, 71.6% of the respondents had a view that it was high as 28.4% of them indicated low in Kibiri ward. Conversely, in Kendu-Bay ward, only 47.1% of the respondents indicated that stone mining was high against majority

52.7% of them with contrary view. Hence, stone mining was found to be more common in Kanyaluo, West Karachuonyo and Kibiri but less common in Kendu Bay ward.

Table 4.9: Perception on stone mining in the area of study

Wards	No. High	% High	No. Low	% Low
Kendu Bay	33	47.1	37	52.7
Kanyaluo	53	84.1	10	15.9
West Karachuonyo	71	79.8	18	20.2
Kibiri	48	71.6	19	28.4
Total	**205**	**70.93**	**84**	**29.07**

Source: Author (2022)

Respondents were also asked to indicate the effect of stone mining in their areas of residence on soil quality particularly in the farming lands. The findings (Figure 4.14) showed that in Kanyaluo ward, 81.0% agreed that stone mining has lowered soil quality in their areas of residence against 19.0% who disagreed while in West Karachuonyo, 78.7% of the respondents agreed as opposed to 21.3% of them who disagreed. In Kibiri ward 65.7% of the respondents agreed on the same against 34.3% who disagreed. However, in Kendu Bay ward, 50.0% agreed that quarrying reduces soil quality in farm lands in their areas of residence while the same number also disagreed. In an average, majority of the interviewed respondents, 69.2%, had the view that stone mining in the area contributes to low soil quality against 30.8 % with contrary.

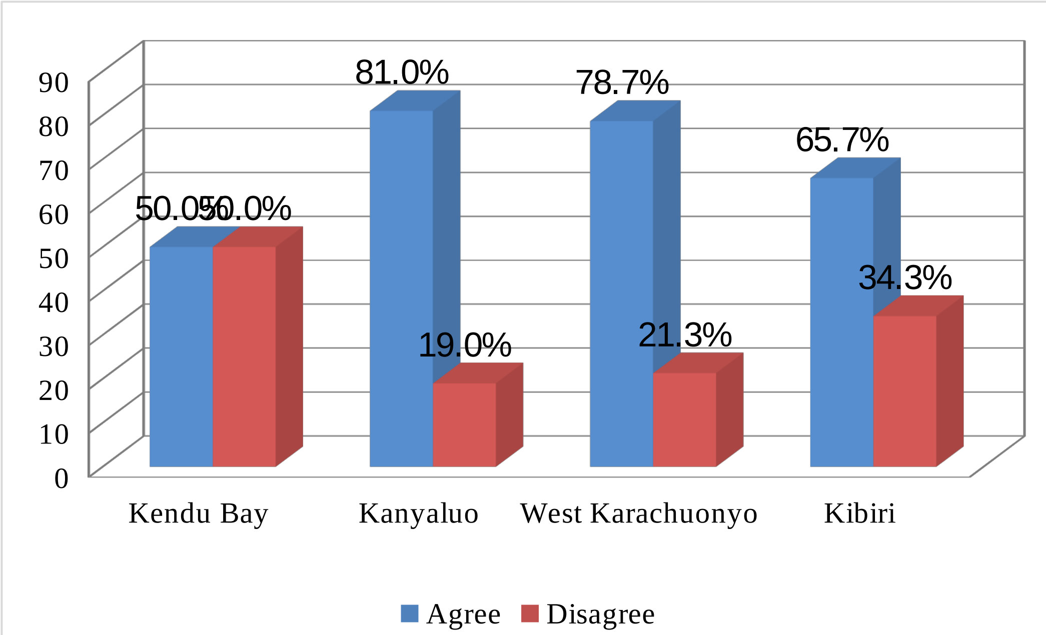

Figure 4.14: *Views on the effect of quarrying on soil quality*

Source: *Author (2022)*

Additionally, photographs taken (Plate 4.8) also revealed how agricultural lands are progressively turning into quarries together with expansion of derelict lands due to stone mining.

Plate 4.8: *Stone mining from cultivatable land in West Karachuonyo ward*
Source: *Author (2022)*

Further, during FGDs, majority of the participants had a view that the main aim of extraction of stones was to provide materials for building and construction both at domestic and commercial levels. During FGD_2 indicated that majority of the households are intensively involved in stone extraction and specifically one of the participants in the discussions argued that quarrying is gradually replacing crop farming in many parts of ward.

> ‘‘*Most residents in this place are highly engaged in stone mining to an extent that majority of the household members are doing quarrying and this has really affected the agricultural lands in this place.*’’

While study (Wangela, 2019) established that stone mining can increase negative environmental consequences such as environmental pollution, by extension, such negative results may also encompass soil degradation which this study has found that destroys some of the farming lands.

4.4 Effect of anthropogenic soil degradation practices on food security situation

The second objective was to establish the relationship between perceived anthropogenic soil degradation practices and food security situation. To achieve this, the results were analyzed thematically and findings shown in table form. Regarding this study, household indicators of food insecurity situation were perceived as high prices of basic food crops especially maize and sorghum, food shortage related stress, the level of monthly expenditure on purchasing staple foodstuff, dependence on relief food from Non-Governmental Organizations (NGOs) and politicians, domestic violence, low living standard, nutritional related diseases, infant mortality and school absenteeism among school going children. These according to Wiesmann *et al* (2006 & 2008) are some of the direct and indirect measurement of food security at household level. When there is an increase of food prices together with low monthly income, food insecurity situation is therefore more evident among the households as opposed to when there is no collapse in the households' income (Marques 2003, FAO, 2019 & Mutea *et al*, 2022). In such case, the knowledge about the level of respondents' monthly income is key in establishing the likelihood that they could indicate whether there is food in/security.

4.4.1 The relationship between the level of households' monthly income and food security situation

Response affirming the presence of food security was coded '0' while absence of food security coded '1' for the purpose of Binary Logistic Regression analysis as guided by

(Hilbe, 2015). Findings (Table 4.11) indicate that majority 95.8% respondents had a view that there is food insecurity in their area of residence, while just 4.2% reported cases of food security. Compared with the level of monthly income, majority of the low income respondents (78.0%), that is, between Ksh.10, 001-25,000, had a view that there is food insecurity.

Table 4.10: Household perception on food security situation in relation to their level of income

Level of monthly income		**Food security (n=12)**	**Food insecurity (n=277)**
Very low	n=1	0.0%	0.4%
Low	n=223	58.3%	78.0%
Average	n=50	41.7%	16.2%
High	n=9	0.0%	3.2%
Very high	n=4	0.0%	1.4%
Satisfactory	n=2	0.0%	0.7%

Source: Author (2022)

4.4.2 Household indicators of food insecurity in the study area

Perceived indicators of food insecurity were examined to establish their prevalence in the study area. To achieve this, respondents were asked to indicate the level of food scarcity. To perform Binary Logistic, responses such as ‘very low’ and ‘low’ were regarded to imply presence of food security while ‘average’, ‘high’ and ‘very high’ as absence of food security. The absence of food security was coded ‘1’ while presence of food security coded ‘0’ which is relates to Hilbe (2015) who argues that to perform Binary Logistic Analysis, variables should be categorized into two major groups and coded as either ‘1’ or ‘0’. This coding technique was considered relevant to this study given that it has been used in both geographic and other research fields including education to successfully analyze dichotomous data. For instance, Muzdalifah *et al* (2020) used it in the analysis of Land Cover Change Phenomenon while Zewude *et al* (2016) applied it in analyzing Factors Influencing Academic Achievement among Students. However, it should be noted that while this technique can be used with both qualitative and quantitative data, for the case of data which are quantitative in nature requires that the data must first be transformed into qualitative forms and reduced to binary format (Hilbe, 2015). Therefore, based on the findings (Table 4.11) which shows that there is high level of food insecurity in the area, respondents were further asked to indicate the level of various perceived indicators of food insecurity.

The findings (Table 4.12) revealed that majority of the respondents 97.6% agreed that food prices were high during most periods of the year while only 2.4% disagreed. Regarding level of expenditure on food, 95.5% of the interviewed respondents were reportedly spending more than 75% of their monthly income on purchasing basic foodstuffs as opposed to only 4.5% whose expenditures on food were 25%. This implies that coupled with low monthly income among the majority of the residents (Table 4.3), large family sizes (Table 4.2), high level of unemployment, the high prices of food together with high level of expenditure on food indicate that there is an overall effects of ‘economic shocks’ which mostly trigger and worsen food insecurity situation (FAO, 2000; Marques, 2003; Utuk & Daniel, 2015; FAO, 2019 & Mutea *et al*, 2022). Moreover, majority 88.9% of the respondents reported to be stressed about food against 32 (11.1%) who had no stress. Asked whether there were cases of domestic violence relating to issues of inadequate food, 61.9% agreed while 38.1% disagreed. Concerning school absenteeism among school going children 40.8% agreed contrary to the majority 59.2% who disagreed. Moreover, in relation to duration respondents stay without having a meal, 94.5% of the respondents were reportedly skipping meals while only 5.5% who did not skip meals. Concerning standard of living, majority of the respondents 73.4% reportedly had low standard of living as compared to 26.6% of them with improved living standard.

Table 4.11: Indicators of food insecurity in the area of study

Indicators	Agree		Disagree	
	n	**%**	**n**	**%**
High food prices	282	97.6	7	2.4
Long duration without meals	273	94.5	16	5.5
Presence of school absenteeism	118	40.8	171	59.2
Presence of domestic violence	179	61.9	110	38.1
Stress related to absence of food	257	88.9	32	11.1
High expenditure on food purchases	276	95.5	13	4.5
Low standard of living	212	73.4	77	26.6

Source: Author (2022)

Considering infant mortality and the level of malnutrition related diseases, during Focused Group Discussion at Kendu Bay ward (FGD_1), participant whose views were also accepted by the rest of the participants said;

> **‘‘***Though we can’t exactly testify about the cause(s) of infant mortality among some of our children, we can at least blame it on malnutrition among our breast feeding mothers as a consequence of inadequate food.***’’**

Further, during Focused Group Discussion at Kanyaluo ward (FGD_2), while one of the participants confirmed that there is low absenteeism among school-going children in the area, another one whose observation was accepted by majority of the participants argued that;

> ***‘‘Some of our children go to school with the hope of getting relief food provided in some of these schools otherwise I don’t think they could be in school when there is no food provided.’’***

Accordingly, in light of Government of Kenya (2016), key among the strategic objectives of providing relief food in schools being first to address the problem of inequalities in food security situation among the learners in Kenya and secondly to improve the learning outcome, these study findings point out that this program has been adopted in the area of study mainly to address the issues of absenteeism due to food insecurity.

4.4.3 Effect of anthropogenic soil degradation practices on food security

When the respondents were further asked to indicate the extent to which different anthropogenic soil degradation practices reduce food security situation in the area, the findings (Table 4.12) show that 96.8% monoculture and farming methods, 93.5% tractor tillage, 84.5% stone mining, 83.0% livestock farming, 80.5% bush clearing and tree cutting, 76.5% sand harvesting as well as 70.8% hill slope cultivation and settlement contribute to food insecurity.

Table 4.12: Summary of effect of human practices on food security

Variables			Food security (n=12)	No food security (n=277)
Bush clearing and tree cutting.	No effect	n=56	16.7%	19.5%
	Affect	n=233	83.3%	80.5%
Sand harvesting	No effect	n=68	25.0%	23.5%
	Affect	n=221	75.0%	76.5%
Livestock farming	No effect	n=51	33.3%	17.0%
	Affect	n=238	66.7%	83.0%
Monoculture and farming methods	No effect	n=10	8.3%	3.2%
	Affect	n=279	91.7%	96.8%
Tractor tillage	No effect	n=20	16.7%	6.5%
	Affect	n=269	83.3%	93.5%
Hill slope cultivation and settlement	No effect	n=84	25.0%	29.2%
	Affect	n=205	75.0%	70.8%
Stone mining	No effect	n=46	25.0%	15.5%
	Affect	n=243	75.0%	84.5%

Source: Author (2022)

Further, when binary logistic regression was performed (Table 4.13), the results indicated that bush clearing and tree cutting was negative and insignificant (B = -0.462, S.E = 0.381 and P< 0.381), predictor of food insecurity. The odd ratio indicates that for every one unit increase on bush clearing and tree cutting, the odds of indicating food insecurity decreased by a factor of 0.63 and hence have a positive correlation to household food insecurity situation. Stone mining was a positive and significant (B= -0.756, S.E = 0.364 and P = 0.038), predictor of food insecurity. The odd ratio indicates that for every one unit increase on stone mining, the odds of indicating food insecurity increases by a factor of 2.131, sand harvesting was a positive though insignificant (B= -0.478, S.E = 0.368 and P = 0.194), predictor of food insecurity. The odd ratio indicates that for every one unit increase on sand harvesting, the odds of indicating food insecurity increases by a factor of 1.613, livestock farming was a positive though insignificant (B= -0.419, S.E = 0.447 and P = 0.349), predictor of food insecurity. The odd ratio (OR) indicates that for every one unit increase on livestock farming, the odds of indicating food insecurity increases by a factor of 1.520. Monoculture was also a positive though insignificant (B= -0.422, S.E = 0.463 and P = 0.362), predictor of food insecurity. The odd ratio indicates that for every one unit increase on monoculture, the odds of indicating food insecurity increases by a factor of 1.525, tractor tillage was a positive and statistically significant (B= -0.961, S.E = 0.489 and P = 0.05), predictor of food insecurity. The odd ratio indicates that for every one unit increase on conventional tillage, the odds of indicating food insecurity increases by a factor of 2.613.

Moreover, hill slope settlement and cultivation was a positive and significant (B= -0.801, S.E = 0.368 and P = 0.0290), predictor of food insecurity. The odd ratio indicates that for every one unit increase on slope settlement and cultivation, the odds of indicating food insecurity increases by a factor of 2.227. Therefore, these findings implies that hill slope cultivation and settlement is 2.227 times likely to cause food insecurity than food security, sand harvesting (1.613), monoculture (1.525), stone mining (2.130) and livestock farming (1.520) times likely to cause food insecurity than food security in Rachuonyo North Sub-County. However, stone mining (OR = 2.130, 95% Cl; $p < 0.05$), conventional-tractor tillage (OR = 2.613, 95% Cl; $p < 0.05$), together with hill slope cultivation and settlement

(OR = 2.227, 95% Cl; p < 0.05) were statistically significant predictors of food insecurity in the area. In relation to stone mining, the findings of this study considerably differ with that of Ming'ate *et al* (2016) that largely glorify stone extraction as an improvement of livelihoods among the residents implying that short term gains of this practice should not be over emphasized at the expense of long term risks, which in this case is its effect of food insecurity. However, there is close nexus between the results of this study and other studies including (Lal, 1997, Langer, 2001, Acharya *et al*, 2008, Moreno *et al*, 2010, Busari *et al*, 2015, FAO, 2015b, Ramsa *et al*, 2018 & Wangelar, 2019) which established that convectional tillage as well as human settlement and cultivation on hill slopes are common human practices which significantly reduce the soil health and consequently cause food insecurity.

Table 4.13: Binary logistic regression model

Predictor variables	**B**	**S.E**	**Wald**	**df**	**Sig**	**Exp(B)**
Bush clearing and Tree cutting	-0.462	0.528	0.768	1	0.381	0.630
Stone mining	0.756	0.364	4.318	1	0.038*	2.130
Sand harvesting	0.478	0.368	1.689	1	0.194	1.613
Livestock farming	0.419	0.447	0.877	1	0.349	1.520
Monoculture	0.422	0.463	0.83	1	0.362	1.525
Tractor tillage	0.961	0.489	3.853	1	0.050*	2.613
Slope settlement and cultivation	0.801	0.368	4.747	1	0.029*	2.227

Model X^2 (7) = 16.279, p < 0.023, Pseudo R^2 values Cox and Snell 0.55 Nagelkerke 0.095. n = 289, *Statistically significant

Source: Author (2022)

4.5. Common soil management and conservation in the area

The third objective was to investigate the most common soil management and conservation measures used in the area of study. To achieve this, the respondents were asked whether they were satisfied or dissatisfied with soil conservation strategies in their area of residence. The results (Figure 4.15) pointed out that majority, 94.8% of the surveyed households were dissatisfied with soil management and conservation in the area while 5.2% were satisfied. This may imply that it is unlikely that the area residents pay attention to soil security management and conservation measures.

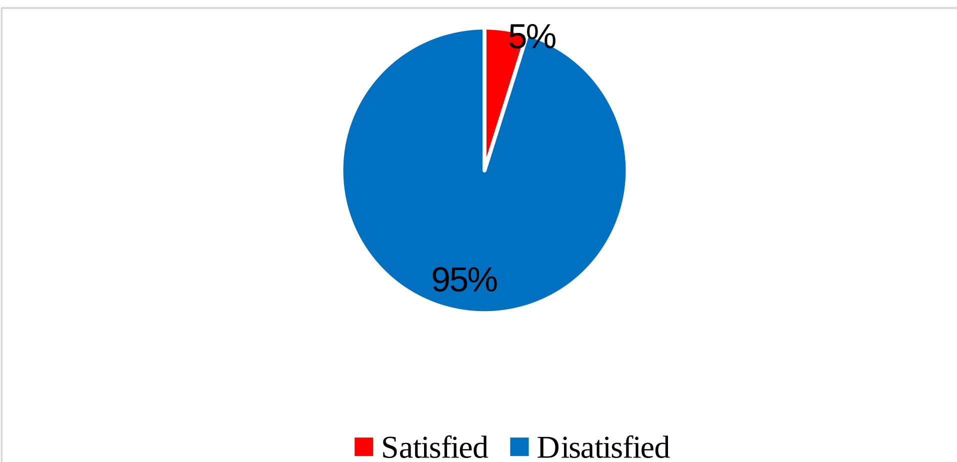

Figure 4.15: *View on soil management and conservation strategies*

Source: *Author (2022)*

Further, the respondents were asked to indicate the level of knowledge in relation to soil management and conservation strategies. This was aimed at evaluating the level of respondents' traditional knowledge which according to Ocelli *et al* (2021) is the leading force behind soil management abilities. The findings (Figure 4.16) show that majority, 76.8% of the households had low level of knowledge about soil management and conservation contrary to only 23.2% with high level of knowledge. This implies that though soil degradation is common in the area (Table 4.5), the majority of the smallholders in the area not likely to engage in soil health maintenance measures, for lack of knowledge. Therefore, this informs the need to roll out learning programs both at household level and community-based level to educate the locals about integrating soil-based conservation ideas including soil nutrients and fertility management.

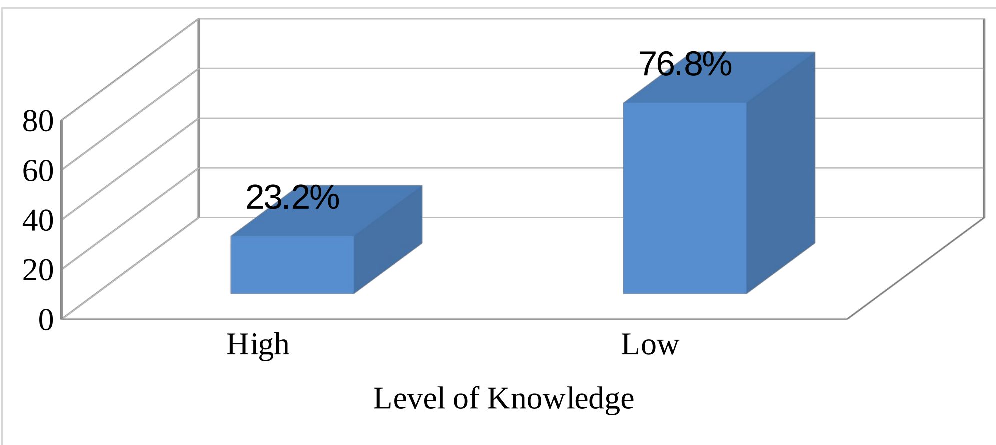

Figure 4.16: *Level of households' knowledge about soil conservation strategies*

Source: *Author (2022)*

When they were further asked to indicate some of the soil conservation measures they are using, the results (Table 4.14) show that while 92.4% felt that crop rotation was low against 7.6% respondents who said it is high, 85.5% of the respondents were reportedly not using organic farming whereas only 14.5% used it. Additionally, findings also showed that majority of the respondents 82.4%, 68.9% and 62.3% felt that agroforestry, communal participation in soil conservation practices and tree planting respectively were hardly practiced. While studies have established that secondary crops (Vanlauwe, 2003 & Sanginga *et al*, 2009), organic agriculture (Vanlauwe *et al*, 2010 & 2011), crop rotation (FAO, 2017), and agroforestry (Vanlauwe *et al*, 2006a; Vanlauwe *et al*, 2006b & Sarvade *et al*, 2017) as some of the best soil management and conservation strategies, the study findings indicate that they are hardly applied in the area of study. This definitely defines the reason why most soils in the study area are vulnerable to soil degradation. However, it was good news that majority of the households, 75.5%, were reportedly practicing mixed farming.

Table 4.14: Perception on soil conservation practices in the study area

Characteristics	Responses	Frequencies	%
Soil management awareness	High	55	19.0
	Low	234	81.0
Level of participation in soil conservation	High	90	31.1
	Low	199	68.9
Level of mixed farming	High	210	72.7
	Low	79	27.3
Level of crop rotation	High	22	7.6
	Low	267	92.4
Level of agroforestry	High	51	17.6
	Low	238	82.4
Organic farming	Yes	42	14.2
	No	247	85.5
Tree planting	High	109	37.7
	Low	180	62.3

Source: Author (2022)

Further, during FGD 1, 2 and 3, it was established that in relation to soil degradation control measures, most of the respondents were not aware about what they could do to reduce the increasing effect of soil degradation in their area of residence while during FGD 4 it was realized that majority of the respondents were concerned about soil degradation though they have given up particularly on intensive gullying processes in their areas of residence. One of the group participants whose comment was commonly accepted by others stated that;

> ***''****This soil is very good for growing maize and sorghum though it is being carried away into the Lake Victoria when it rains. This has led to formation of many deep surface cuts in this area which are continuously expanding into our farms but we can't help.****''***

Photographs taken during Direct Field Observation also show the presence of large gullies (Plate 4.9) that are extending into the nearby agricultural lands.

Plate 4.9: *Gully formation in West Karachuonyo ward*
Source: *Author (2022)*

Results of the Key Informant Interviews concerning tree planting reveal that the few who plant trees do so not with soil conservation in mind but with an intention of cutting them in future for commercial based related reasons while on the other side regarding agroforestry, most of the Key Informants acknowledged its relevance and ecosystem related benefits particularly in soil conservation. However, they argued that the pace of its adoption is slow among the area residents. In relation to this, in one of the KII argued that;

> **‘‘***Though most people don’t consider its importance, we encourage the engagement of the local residents in planting crops together with or within the trees through fruit-tree technology.***’’**

Lastly, during FGD_3, majority of the participants had a view that some of the area residents apply organic manure, which has not decomposed, into their farms while others use industrial fertilizers a practice which Fairhurt (2012) cautions as unsustainable when it comes to soil nutrient management. Considering ‘continuous cultivation’, one of the participants during FGD_4 stated that;

> **‘‘***Majority of farmers practice continuous cultivation of mainly maize and sorghum, without allowing their farms to ‘rest’ for at least one planting season. However, the few household farmers who leave their farms to ‘rest’ for at least one planting season record improved crop yield*.**’’**

It is due to these findings which are helpful in understanding that intensive as well as continuous cultivation lead to intensive utilization of soil microbial (Anelia *et al*, 2012) which according to (Killebrew & Wolff, 2010 & Marais *et al*, 2012) reduces soil organic matter hence leading to depletion of soil nutrients and ultimately leads to low crop yield or total crop failure. To reverse this, household farmers should be encouraged to adopt ‘farm-rest’ period as opposed to continuous cultivation during which they should plant legumes which according to Vanlauwe *et al* (2006a) are important in protecting the soil structure.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter is comprised of conclusions of research findings, recommendations as well as suggestions for further readings.

5.1 Summary of the findings

This study used a detailed household-level data from 289 households, four FGDs comprising of 3 to 4 members of mixed gender, five KII, and a binary logistic regression model to analyze the impacts of anthropogenic soil degradation practices on household food security among smallholder farmers in Homa-Bay County, Kenya. The study found that 50.2% of the respondents were male while 49.8% were female and this was an equal gender representation. The majority, 54.0%, of the household heads were between 40 - 79 years of age, while 50.2% had primary level of education.

Furthermore, the findings on the most common anthropogenic activities causing soil degradation in the area show that 85.1% of the respondents viewed soil degradation as a consequence of bush clearing and tree cutting with majority of them, 80.3%, agreeing that this has contributed to soil quality reduction. FGDs and KII participants also agreed that cutting of trees is one of the major causes of soil degradation in their area. Further, while 96.2% of the respondents indicated that continuous cultivation of crops such as maize and sorghum has resulted to soil degradation a view similar to that of KII, majority of the respondents, 80.6%, had noted that some of these methods of cultivation such as tractor tillage and cultivation on the steep hill slopes have led to soil degradation in the area with 92.8% of the respondents reporting that the manner in which tractor cultivation is used has reduced soil health significantly.

Moreover, majority, 79.6%, of the respondents reported that farming and settling on the hill slopes subject the soils in these areas to rapid run-offs hence causing soil degradation. Additionally, while 85.8% of the respondents agreed that livestock farming is common in the area, results of FGDs show that it entails overstocking and indiscriminate grazing which in their view compromises the quality of the soil. Majority of the households, 69.2%, also reported that stone mining is practiced in their areas of residence while just 29.8% of them agreed that sand harvesting is common in the agricultural lands within their areas of residence. 83.8% and 76.2% of the respondents indicated that stone mining and sand harvesting respectively have reduced soil quality in the study area. Concerning food security situation among the households, the findings established that 95.8% of the residents are food insecure.

Regarding household-based indicators of food insecurity situation, while majority of the respondents, 97.6%, had a view that there is high cost of staple food crops particularly maize and sorghum, 95.5% reported that there is high expenditure on purchasing food. Majority of the household heads also indicated that there was uncertain food frequency (94.5%), high stress related to food accessibility (88.9%), household low standard of living (73.4%), and high cases of domestic violence (61.9%) while school absenteeism was reportedly at 40.8%. This was alongside low monthly income (94.5%) and high cases of unemployment (85.1%) among the household.

Regarding the effect of anthropogenic soil degradation activities on food security situation, the results showed that 80.3% of the respondents viewed bush clearing and tree cutting as one of the major contributor to low crop yield while 96.2% of the respondents perceived continuous cropping to lower crop yield in the area. Additionally, 92.8% of the respondents had a view that tractor cultivation results to crop failure while 70.7% of them indicated that intensive hill slope settlement and cultivation affect negatively the level of food crop production in the area. Moreover, 83.1% of the respondents reported that livestock rearing increase cases of low agricultural performance in the area while majority of the respondents, 76.2% and 83.8% also perceived sand harvesting and stone mining respectively to be conditioning crop yield. Lastly, the findings from Key Informants, opinion drawn from FGDs and Field Based Observations showed a close relation to those of the respondents that anthropogenic practices contribute to soil degradation which consequently threaten food security situation in the area of study.

Further, results of the binary logistic regression analysis indicated that bush clearing and tree cutting was negative and insignificant (B = -0.462, S.E = 0.381 and P< 0.381), predictor of food insecurity. Stone mining was a positive and significant (B= -0.756, S.E = 0.364 and P = 0.038), predictor of food insecurity. Sand harvesting was a positive though insignificant (B= -0.478, S.E = 0.368 and P = 0.194), predictor of food insecurity, livestock farming was a positive though insignificant (B= -0.419, S.E = 0.447 and P = 0.349), predictor of food insecurity, monoculture was also a positive though insignificant (B= -0.422, S.E = 0.463 and P = 0.362), predictor of food insecurity, tractor tillage was a positive and statistically significant (B= -0.961, S.E = 0.489 and P = 0.05), predictor of food insecurity. Additionally, hill slope settlement and cultivation was a positive and significant (B= -0.801, S.E = 0.368 and P = 0.0290), predictor of food insecurity.

Additionally, the results on the common soil management and conservation strategies practiced in the area indicated that first, 94.8% respondents are not satisfied with the manner in which soil conservation is done in the study area. Further, in relation to the level of knowledge on soil management measures, 79.0% of the respondents reported to have low knowledge about the ideal soil conservation as well as management practices. Regarding the level of communal participation in soil conservation initiatives, 67.9% of the surveyed respondents were not participating in community-based soil conservation initiatives. Further, 62.1% of them were not involved in either afforestation or reforestation yet the majority of the respondents who were involved in either of these were having the intention of cutting them in future for commercial and/or domestic use, as revealed during Focused Group Discussions and KII. Regarding crop rotation (91.4%), of the respondents also reported low level of the same. The low level of agroforestry (17.9%) and limited organic farming (13.1%) were also reported.

5.2 Conclusion of the study

This study therefore concludes that monoculture and continuous cultivation (96.2%), tractor tillage (92.8%), livestock farming (85.8%), stone mining (83.8%), tree cutting and bush clearing (83.1%), hill slope-based farming and settlements (80.6%) as well as sand harvesting (76.2%) are the most common anthropogenic practices in the study area. In relation to the extent to which they reduce soil quality, the study concludes that livestock husbandry (86.4%), tree cutting and bush clearing (84.8%), conventional-tractor cultivation (84.1%), monoculture and continuous cultivation (82.0%), hill slope farming and settlement (79.1%) together with stone mining (68.9%) have contributed to soil degradation in Rachuonyo North Sub-County. However, sand harvesting (31.5%) has less effect on soil health which can be attributed to the fact that its extraction is mostly common in some of the rivers particularly during the rainy season and partly the shores of Lake Victoria as opposed to farming lands.

This therefore implies that there is need to control the effects of all these anthropogenic practices on soil degradation by coming up with sustainable land-use and land cover framework and policy guidelines to aid in transforming them from soil degradation-based practices to soil health restoration and management on a sustainable basis.

Regarding the impact of anthropogenic soil degradation practices on food security, the study concludes that among the investigated practices using Binary Regression Analysis, stone mining (OR = 2.130, 95% Cl; $p < 0.05$), tractor tillage (OR = 2.613, 95% Cl; $p < 0.05$), together with hill slope cultivation and settlement (OR = 2.227, 95% Cl; $p < 0.05$) are statistically significant hence accurate predictors of food insecurity situation in the area of study. Therefore, policies encouraging and popularizing the use of tractor cultivation in the area of study ought to be reviewed and re-oriented to the advantage of soil security suitability. Further, the guidelines for near or hill slope cultivation and settlement in the study area should be re-evaluated to seal the gaps which enable human encroachment into the high elevated areas such as forested hills. In addition to these, stone mining should be site-specific that is, designated to specific areas within the study area as opposed to extraction even from rich farming lands.

Finally, concerning common soil management and conservation strategies in the study area, this study concludes that apart from mixed farming which is relatively practice in the area of study, other soil management and conservation measures such as organic farming, tree planting, crop rotation, agroforestry, participation in community-based soil conservation initiatives, are absent. Therefore, they should be adopted in an effort to stop soil degradation as well as recovering the area's already degraded soils.

5.3 Recommendations

This study recommends interventions relating to specific anthropogenic activities which have been established to be the major cause of soil degradation hence significantly leading to food insecurity situation in the study area. Further, it also details recommendations on other anthropogenic practices which though insignificantly increasing food insecurity situation; they are accurate estimates of soil degradation in the area of study. These recommendations are entailing actions to be taken by local residents as well as both county and national governments.

i. To address the problem of soil degradation caused by human settlement and cultivations on steep hill slopes, which lead to reduction in forests and other vegetation cover, the County Government of Homa-Bay should consider establishing the Ministry of Forestry and Forest Reserves to disintegrate it from the existing Ministry of Water, Environment and Natural Resources. It should be strengthened through giving it its own budget allocation and charged with the responsibilities oversight role, formulation and implementation of forest policies and standards as well as inspecting forest management structures in elevated zones particularly Homa-Hills.

ii. The established Ministry of Forestry and Forest Reserves should submit to the County Assembly of Homa-Bay a report on a monthly basis detailing the progress and gaps arising from implementing its mandates.

iii. The county government should partner with the national government to consider discouraging the local residents from advancing into the established forest reserves and protected areas including the slopes of Homa Hills. Where appropriate and necessary, the study recommends the use of law enforcement bodies to ensure compliance in relation to this.

iv. Through the use of GIS and remote sensing, the national government should erect appropriately the cut-lines around Homa Hills, whose slopes extend to most parts of the area of study, in such a manner that beyond which no human activities including settlement and cultivation should be tolerated.

v. To address the problem of soil degradation caused by intensive and inappropriate methods of tractor cultivation, tractor users should be educated on the geological and pedological structures of the area of study. Further, they are supposed to be informed about how they can vary tractor tillage to ensure minimal soil disturbance.

vi. The local household farmers should be educated and advised on the benefits of embracing alternative tillage methods including oxen-plough, which though according to many households may be facing off in the contemporary society, is the most conservational tillage mechanism.

vii. Regarding the effect of stone extraction on soil degradation, the Homa-Bay County Government through the county assembly should come up with land use policies detailing zones allocated for each both agricultural and non-agricultural activities. This will help in ensuring that there are specifically designated zones for stone mining away from agriculturally active lands.

viii. To effectively improve forest and other vegetation cover in the area, the County Government of Homa-Bay should established county-based community associations, cooperatives as well as encouraging both public and private companies to participate in sustainable tree management technologies including planting trees such as eucalyptus, Mukau (*Melia volkensii*) and Neem (*Azadirachta indica*) because in addition to their ability to grow fast and resist the effect of water insecurity, they are also suitable in soil conservation (Chamberlin *et al*, 2001 and Mutua *et al*, 2014).

ix. The two levels of governments should encourage the locals to intensively grow fruit trees such as thorn melon, guava trees, pawpaw trees, banana trees, and mangoes at their homestead level. This will help improve the biodiversity, soil protection as well as its underlying benefits of providing fruits for domestic consumption

x. The Non-Governmental Organizations should be encouraged by the national and county governments to provide adequate water tanks, both at household level as well as in all public institutions, for storing rain waters which is essential for irrigating the planted trees including fruit trees especially during short rains.

xi. To address the problem of soil degradation caused by poor agronomic practices including unsustainable cultivation methods in the area, both national and county governments should support the local residents through farming-based extension services.

xii. To ensure that information concerning soil conservation strategies and initiatives reach all households, the County Government of Homa-Bay through the Ministry of Agriculture, Livestock and Fisheries should register all household small-scale farmers. Follow up advisories such as periodic community education, digitalized sensitization through the use of direct short messages should be frequently utilized to reach every household.

xiii. Households should also be supported by all stakeholders including the county and national governments to adopt farming technologies which are sustainable. These may include encouraging the use of locally available organic manure, review the current advisories advocating for the use of industrial fertilizers, encouraging maximum retention of crop residues in the farms, avoiding cultivation across the contours, adoption of mixed and rotational cropping aimed at maintaining soil security as well as recovering soil nutrients for sustainable farming of crops particularly maize and sorghum in the area of study.

xiv. The soils in the area of study and the smallholders therein should not be targeted to experiment the suitability of industrial fertilizers, herbicides as well as improved maize and sorghum seeds because they lead to reduction in soil nutrient which unnecessarily increases the cost of farming in the area.

5.3.1 Suggestions for further research.

This study considers the importance of an advanced understanding of the influence of soil degradation on food situation in Kenya and further need for strategic solution. Therefore, the study suggests, for further research;

1. A replicate of this study in other Sub-Counties proximate to the study area particularly practicing different anthropogenic and agronomic activities.

2. A study on effect of land degradation on human settlement among the households of Homa-Bay County in Kenya.
3. Mapping of areas prone to soil degradation in the sub-county.

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APPENDICES

APPENDIX I: OBSERVATION SCHEDULE ON INDICATORS OF SOIL DEGRADATION, FOOD INSECURITY AND SOIL CONSERVATION STRATEGIES.

Identification Details

Ward____________________________ **Location______________________________**

Sub location______________________ **Observation date______________________**

Observable items	**Indicators**	**Observed**	**Not observed**	**Remarks**
	Field sheeting			
	Stone appearance			
	Reduction of vegetation cover			
	Appearance of tree roots			

Indicators of soil degradation	Terraces slides			
	Bending of electric poles			
	Bending of fences			
	Accumulation of soil along the roads and footpaths			
	Bare hill slopes			
	Bare surfaces			
	Field gullying			
Perceived anthropogenic activities causing soil degradation	Level of monocropping			
	Intensity of hill side cultivation			
	Level of tree clearing			
	Level of bush clearing			
	Intensity of sand harvesting			
	Mining			
	Quarrying			
	Livestock farming			
Indicators of food insecurity	Dependence on relief food			
	Increased prices of food			
	Malnutrition and health conditions			
	Low living conditions			
	Organic farming			

Soil management strategies in the sampled areas	Planting of vegetation such as trees			
	Mulching practices			
	Agroforestry			
	Mixed farming			

APPENDIX II: QUESTIONNAIRES FOR THE HOUSEHOLD HEADS

PREAMBLE

My name is **Wicklife Ojallah,** Masters Student from Moi University, Department of Geography and Environmental Studies. I am doing research on Effect of Soil Degradation on Food Security. The purpose of this questionnaire is to collect data on anthropogenic activities causing soil degradation, effects of soil degradation on food security in Rachuonyo North Sub County and the common soil conservation and management strategies in the area. Your participation will be highly appreciated.

SECTION A: Demographic and Socio-economic Characteristics (*Tick appropriately*)

1. Gender of the respondent

   ☐Male ☐Female

2. Age of the respondent (in years)

□Below 20 □21-30 □31-40 □Above 40

3. Kindly mark the level of education

   □Primary □Secondary □Tertiary

   Others (specify)____________

4. How long you have lived in the area (years)

   □Below 5 □6-10 □16-20 □21-25 □Above 30

5. Employment status

   □Formal Employment □Informal Employment

6. Number of family members

   □Below 4 □5-7 □8- 10 □11-13 □Above 14

7. Household heads level of monthly income in Ksh.

   □Below 10,000 □10,001-25,000 □25,001-40,000 □Above 40,000

Section B: Data on anthropogenic practices causing soil degradation *(Tick appropriately)*

1. What do you think is the extent of soil degradation in your area?

   □Very low □Low □Average □High □Very high

2. Do you agree or disagree that the major causes of soil degradation in your area of residence are human based practices?

   □Strongly agree □Agree □Undecided □Disagree □Strongly disagree

3. Do you agree or disagree that forest and bush clearance is a common practice in your area of residence?

   ☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

4. What do you think is the level of forest and bush clearance in your area of residence?

   ☐Very low ☐Low ☐Average ☐High ☐Very high

5. At what rate do you think the level of forest and bush clearance affect soil quality in your area of residence?

   ☐Very low ☐Low ☐Average ☐High ☐Very high

6. Do you agree or disagree that mining and quarrying are some of the major human practices in your area of residence?

   ☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

7. What do you think is the level of mining and quarrying in your area of residence?

   ☐Very low ☐Low ☐Average ☐High ☐Very high

8. At what rate do you think the level of mining and quarrying affect soil quality in your area of residence?

   ☐Very low ☐Low ☐Average ☐High ☐Very high

9. Do you agree or disagree that sand harvesting is commonly practiced in your area of residence?

   ☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

10. What then do you think is the level of sand harvesting in your area of residence?

    ☐Very low ☐Low ☐Average ☐High ☐Very high

11. At what rate do you think the level of sand harvesting affect soil quality in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

12. Do you agree or disagree that livestock farming is one of the major economic practices in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

13. What then do you think is the level of livestock farming in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

14. At what rate do you think the level of livestock farming affect soil quality in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

15. Do you agree or disagree that continuous cultivation of maize crop is commonly practiced in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

16. Do you agree or disagree that continuous cultivation of maize crop reduces soil quality in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

17. How do you think continuous cultivation of maize crop has affected its level of production in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

18. Do you think that continuous cultivation of sorghum crop is commonly practiced in your area of residence?

☐Yes ☐No

19. Do you agree or disagree that continuous cultivation of sorghum crop reduces soil quality in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

20. How do you think continuous cultivation of sorghum crop has affected its level of production in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

21. How satisfied or dissatisfied are you with the level of crop rotation in your area of residence?

☐Very satisfied ☐Satisfied ☐Neutral ☐Dissatisfied ☐Very dissatisfied

22. How do you think the level of practice of crop rotation in your area of residence reduces soil quality?

☐Very low ☐Low ☐Average ☐High ☐Very high

23. Do you think cultivation and settlement on the hill slopes are common practices in your area of residence? ☐Yes ☐No

24. If yes, what is the level of cultivation and settlement on the hill slopes in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

25. At what rate do you think the level of cultivation and settlement on hill slopes affect soil quality in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

26. Do you agree or disagree that most people in your area of residence prefer the use of tractors to cultivate their farms?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

27. To what extent do you think tractor cultivation practice reduces soil quality in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

28. Do you agree or disagree that most people in your area of residence prefer the use of oxen to cultivate farms?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

29. To what extent do you think oxen plough practice reduces soil quality in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

30. Do you agree or disagree that most people in your area of residence prefer the use of hand to cultivate farms?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

31. To what extent do you think hand cultivation practice reduces soil quality in your area of residence?

☐Very low ☐Low ☐Average ☐High) ☐Very high

Section C: Data on relationship between soil degradation and food security. *(Tick appropriately)*

32. Do you agree or disagree that your area of residence experiences longer periods of food scarcity during the year?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

33. What do you think is the level of food scarcity in your area of residence?

☐Very Mild ☐Mild ☐Moderate ☐Extreme ☐Very Extreme

34. What is the level of food prices during most periods of the year?

☐Very low ☐Low ☐Average ☐High ☐Very high

35. How much do you spend on food from your monthly income?

☐Less than 10% ☐10-25% ☐26-50% ☐51-75% ☐More than 75%

36. How often do you find yourself worried about what you will eat in the next meal?

☐Hardly ☐Rarely ☐More often ☐Always

37. Do you agree or disagree that most your family frequently faces cases of malnutrition during some parts of the year?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

38. Do you think that there are some cases of domestic violence in your area of residence caused as a result of food scarcity?

☐Yes ☐No

39. Do you agree or disagree that there are cases of infant mortality due to malnutrition in the area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

40. Do you think that there are cases of school absenteeism among school going children that occur due to food insecurity in your area of residence?

☐Yes ☐No

41. If yes, what do you think is the level that food insecurity increases cases of absenteeism among school going children in the of area residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

42. Do you agree or disagree that the living conditions among majority of the residents is generally low in the area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

43. What do you think is the average level of living standards of residents in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

44. Do you agree or disagree that the level of low soil quality reduces the level of crop yield which consequently increases cases of food insecurity in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

45. What do you think is the level of effect of low soil quality on crop yield in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

46. What is the level of crop yield in your farms after the periods the farm is left without cultivation?

☐Extremely low ☐Low ☐Average ☐High ☐Extremely high

47. What do you think is the level of farm yield for the residents using tractors to plough their farms in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

48. What do you think is the level of farm yield for the residents using oxen plough in your area of residence?

☐Extremely low ☐Low ☐Average ☐High ☐Extremely high

49. What do you think is the level of farm yield for the residents using hand cultivation in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

50. Do you agree or disagree that the level of crop yield for the residents using tractors is low as compared to farmers using oxen plough in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

51. Do you agree or disagree that the level of crop yield for the residents using oxen plough is high as compared to farmers using hand plough in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

52. Do you agree or disagree that cultivation at the slopes of the hills continuously lower the level of crop yield in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

53. What then do you think is the level of crop yield for residents cultivating at the slopes of the hills in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

54. Do you agree or disagree that the level of sand harvesting affects the level of crop yield in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

55. What is the level of crop yield in areas sand harvesting is highly practiced in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

56. Do you agree or disagree that the level of mining and quarrying affect the level of crop yield in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

57. What do you think is the level of farm yield in areas where mining and quarrying are mostly practiced in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

58. Do you agree or disagree that continuous cultivation of maize in your area of residence has affected its subsequent yield?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

59. What is the extent by which continuous cultivation of maize has reduced level of its yield in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

60. Do you agree or disagree that continuous cultivation of sorghum in your area of residence has affected its subsequent yield?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

61. What is the extent by which continuous cultivation of sorghum has reduced level of its yield in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

62. How is the level of crop yield in areas where land is mostly bare due to bush clearing and tree cutting in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

63. Do you agree or disagree that the level of crop yield is low in places where animals are frequently grazing in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

64. What do you think is the level of effect of pest and diseases on crop yield in your area of residence as compared to soil degradation?

☐Very low ☐Low ☐Average ☐High ☐Very high

Section D: Data on common soil management and conservation measures. ***(Tick appropriately)***

65. How satisfied or dissatisfied are you with soil conservation strategies in your area of residence?

☐Very dissatisfied ☐Dissatisfied ☐Satisfied ☐Very satisfied

66. What is your level of awareness about soil degradation in your area of residence?

☐Extremely low ☐Low ☐Average ☐High ☐Extremely high

67. What do you think is the level of participation of area residents in soil conservation in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

68. What is the level of tree planting in your area of residence?

☐Very mild ☐Mild ☐Moderate ☐High ☐Very high

69. Do you agree or disagree that the level of crop rotation in your area of residence is low?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

70. How often do you think mixed cropping is practiced in your area of residence?

☐Never ☐Hardly ☐Often ☐Very often

71. What is the level of cultivation of crops in areas covered by forest in your area of residence?

☐Very low ☐Low ☐Average ☐High ☐Very high

72. Do you agree or disagree that the level organic farming hardly practiced in your area of residence?

☐Strongly agree ☐Agree ☐Undecided ☐Disagree ☐Strongly disagree

73. What do you think is the level of knowledge among the local residence on soil conservation measures in your area?

☐Very low ☐Low ☐Average ☐High ☐Very high

*******THANK YOU FOR PARTICIPATING******

APPENDIX III: MATRIX OF SAMPLED QUESTIONNAIRE AND INTERVIEW QUESTION GUIDE

Methods	Research question	Major variables
Questionnaire	1. What do you think is the level of soil degradation in your area of residence?	Extent of soil degradation in the area.
	2. Do you agree or disagree that the major cause of soil degradation in your area of residence are human practices?	Human practices causing soil degradation.
	3. What is the level of food scarcity in your area of residence?	Extent of food insecurity
	4. What is the level of effect of human practices causing soil degradation on soil quality in your area of residence?	Main human practices causing soil degradation
	5. How does crop yield vary with the effect of different perceived human practices causing soil degradation in the area?	Level of effect of soil degradation on food insecurity.

Interview	1. What do you think is the level of soil degradation in Rachuonyo North Sub County? 2. How does the level of soil degradation vary from one area to another in Rachuonyo North Sub County? 3. What is the role of human practices on soil degradation in the area? 4. To what extent do you think the level of soil degradation affect agricultural performance in the area? 5. What are the role of the local community, county and national governments on soil management and conservation in the area?	Level of soil degradation. Extent of soil degradation. Main human practices causing soil degradation. Strength of association between soil degradation and food insecurity. Soil management and conservation strategies in the area.

APPENDIX IV: OBSERVATION SCHEDULE ON INDICATORS OF SOIL DEGRADATION, FOOD INSECURITY AND SOIL CONSERVATION AND MANAGEMENT STRATEGIES.

Observable items	**Indicators**
Indicators of soil degradation	Field sheeting Stone appearance Reduction of vegetation cover Appearance of tree roots Terraces slides Bending of electric poles Bending of fences Accumulation of soil along the roads and footpaths Bare hill slopes Bare surfaces Field gullying
Perceived anthropogenic activities causing soil degradation	Level of monoculture Intensity of hill side cultivation Level of tree clearing Level of bush clearing Intensity of sand harvesting Mining Quarrying Livestock farming
Indicators of food insecurity	Increased prices of food Low living conditions
Soil conservation and management measures	Organic farming Afforestation and reforestation Mulching practices Agroforestry

	Mixed farming Crop rotation

APPENDIX V: PEARSON CORRELATION RESULT OF RELIABILITY TEST FOR QUESTIONNAIRE QUESTIONS

Variables	**Items**	$\mathbf{r_1}$	$\mathbf{r_2}$
Human based practices	Pearson Correlation	01	0.545*
	P value	-	0.013
	n	20	20
Food security	Pearson Correlation	0.545*	01
	P value	0.013	-
	n	20	20

R = + 0.545, P < 0.013 and n=20

APPENDIX VI: Z TABLE FOR DETERMING CONFIDENCE LEVEL.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900
3.1	.99903	.99906	.99910	.99913	.99916	.99918	.99921	.99924	.99926	.99929
3.2	.99931	.99934	.99936	.99938	.99940	.99942	.99944	.99946	.99948	.99950
3.3	.99952	.99953	.99955	.99957	.99958	.99960	.99961	.99962	.99964	.99965
3.4	.99966	.99968	.99969	.99970	.99971	.99972	.99973	.99974	.99975	.99976
3.5	.99977	.99978	.99978	.99979	.99980	.99981	.99981	.99982	.99983	.99983
3.6	.99984	.99985	.99985	.99986	.99986	.99987	.99987	.99988	.99988	.99989
3.7	.99989	.99990	.99990	.99990	.99991	.99991	.99992	.99992	.99992	.99992
3.8	.99993	.99993	.99993	.99994	.99994	.99994	.99994	.99995	.99995	.99995
3.9	.99995	.99995	.99996	.99996	.99996	.99996	.99996	.99996	.99997	.99997

APPENDIX VII: RESEARCH AUTHORIZATION.

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KENYA

DEPARTMENT OF GEOGRAPHY & ENVIRONMENTAL STUDIES

24th FEB.2022

To
The Director,
National Commission for Science, Technology and Innovation

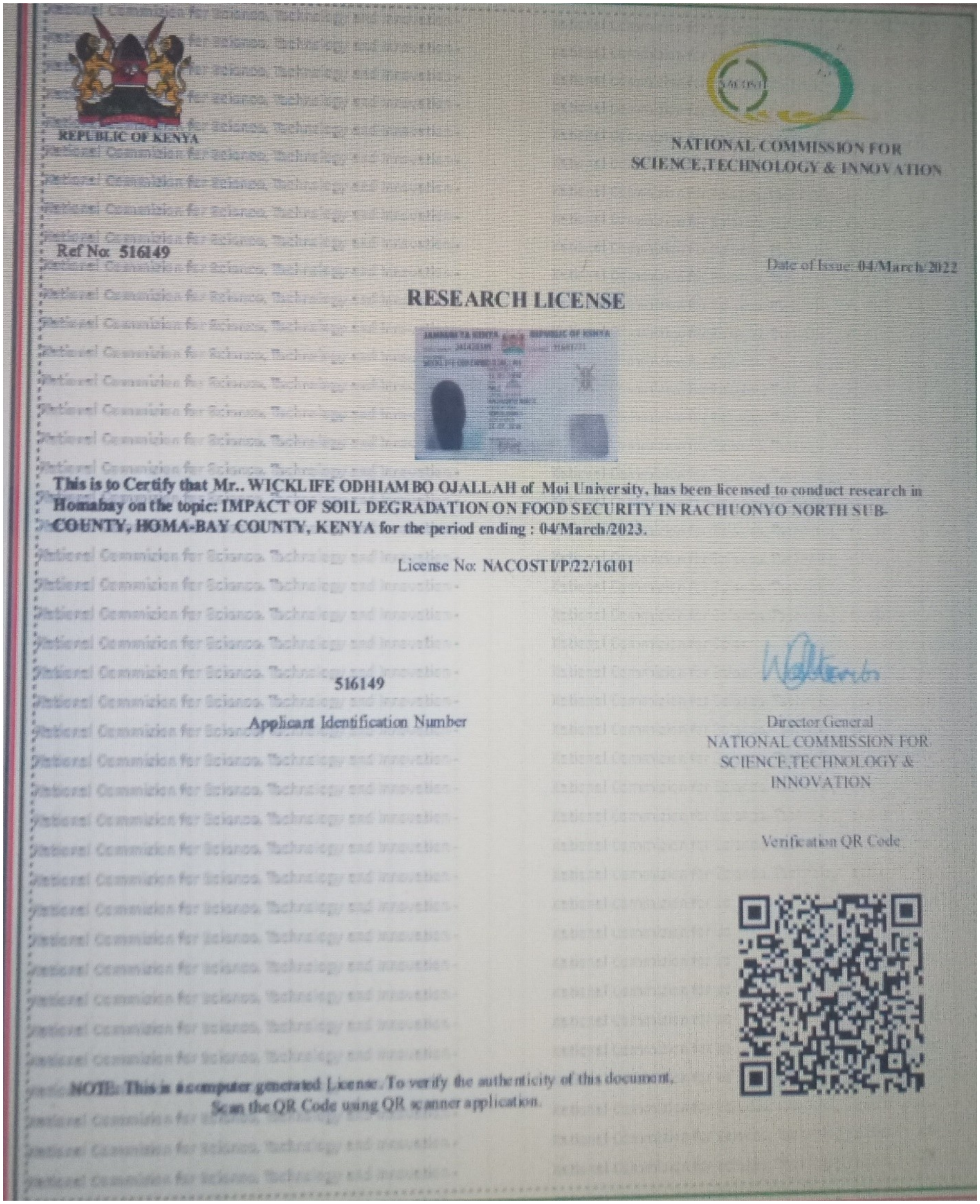
RE: RESEARCH PERMIT FOR OJALLA WICKLIFE ODIAMBO: MS/GEO/4177/20

This is to certify that Mr. Ojalla Wicklife Odhiambo is a masters student in the department of Geography & Environmental Studies, Moi University. He successfully presented his research proposal entitled ***"Impact of Soil Degradation on Food Security in Rachuonyo North Sub County in Homabay County, Kenya"*** at a departmental seminar held on 22nd March 2021. The department has therefore cleared him to proceed to the field for data collection. Kindly assist him process research permit to enable him undertake data collection.

Thanking you in advance.

Yours faithfully,

Dr. Raphael W. Kareri
Chair, Department of Geography & Environmental Studies



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 516149

Date of Issue: 04/March/2022

RESEARCH LICENSE

This is to Certify that Mr.. WICKLIFE ODHIAMBO OJALLAH of Moi University, has been licensed to conduct research in Homabay on the topic: IMPACT OF SOIL DEGRADATION ON FOOD SECURITY IN RACHUONYO NORTH SUB-COUNTY, HOMA-BAY COUNTY, KENYA for the period ending : 04/March/2023.

License No: NACOSTI/P/22/16101

516149

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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