Effect of Soil Degradation on Households' Food Security in Rachuonyo North Sub-County, Homa-Bay County, Kenya

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Abstract.

This study assessed the effect of soil degradation on food security among households (HHs) of Rachuonyo North Sub-County, Homa-Bay County in Kenya. It examined common Anthropogenic Practices (ATPs) causing soil degradation, established the nexus between soil degradation and food security among the HHs and identified appropriate strategies for mitigating the effect of ATPs on soil degradation to improve food security in the area. Theory of Praxeology was considered relevant to the study. While study population was 32,500 households, Cochran formula was used to obtain 289 samples identified using multi-stage together with simple random sampling techniques for quantitative data. Five Key Informants were purposively identified for qualitative data. It was a cross-sectional survey study design. Data analysis involved descriptive and inferential statistics 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. While the findings linked soil degradation to ATPs, for the investigated practices, BLRDA results revealed 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; $p < 0.05$) are more prevalence. Study concludes that these ATPs are the major cause of soil degradation resulting to food insecurity threats among the HHs in the study area. The study recommends suspension of ATPs on high elevations in the area particularly Homa-Hills, review stone extraction and tractor farming policies, introduce intensive afforestation and reforestation.

Introduction

In relation to soil components, 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 while its importance in view of Brevik et al. (2009) is primarily relating to its function of providing nutritional contents in addition to 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. This represents about 22% of the agricultural lands, grazing zones, forest as well as other essential vegetation. Accordingly, Murtaza et al. (2016) argues that the usually notable pointers of soil degradation are nutrient depletion such as reduction in Soil Organic Content (SOC) as well as deteriorated soil physical properties such as soil structure, soil texture, imbalance in soil nutrient status. At the global scale, the soil degradation data revealed that degradation in Europe is about 60% to 70% (Feddama et al., 2001; FAO, 2005; Fischer et al., 2008 & Bagarello, 2017), and the Asian soil is about 40% degraded (Alam, 2014) while 65% to 75% of the Sub Saharan (SSA) soil is degraded (Tully et al., 2015). Therefore, this accelerated loss of arable land to soil degradation, which ultimately reduces the level of agricultural output is a global concern (UNGA, 2013; UNGA, 2014 & FAO, 2015), which potentially signifies restricted sustainable development of economies of many countries globally (Lal, 2007; Gowing, 2008; Bindraban et al., 2010; Bindraban et al., 2012, Sayeed, 2013; Boulanger et al., 2018 & Chunyan et al., 2020). Consequently, this may advance the effect on food insecurity (KFSSG, 2011 & 2018). Looking at Africa, especially SSA for example, whose most livelihoods of many rural households largely depend on agricultural activities (Mugizi & Matsumoto, 2020), soil degradation may worsen the well-being of human life (Zingore, et al., 2015 & Gomiero, 2016). While Tully et al. (2015) argue that among other causes, increased unsustainable agricultural practices in efforts to feed the ever growing human population in Africa leads to reduction in soil health, Africa's extent of soil degradation is higher in arid and semi-arid areas (ASALs) as compared to humid zones (see Thiombiano, 2007; Keyzer et al., 2011; Bindraban et al., 2012 & Zingore et al., 2015).

Just like many African countries within the SSA region, Kenya's soils have 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 country's economy as a whole (Birch, 2018 & Eichsteller et al., 2022). This informs the efforts by Kenya's government to ensure that farming is adequately enhanced with the hopes that this will contribute to the achievement of the famous blue print "Vision 2030", which is anchored on adequate food supply to eliminate food insecurity among the citizens (Jowi, 2016).

Accordingly, Muia and 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 counties in Kenya are facing the risk of various forms of soil degradation with ASALs counties highly affected because of the high soils erodibility coupled with

increased intensity storms, surface run-off and soil erosion (LADA, 2016). For example, Homa-Bay County has great agricultural potential, probably more than any other ASAL counties in Kenya, which has never been achieved (GoK, 2013 & GoK 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 study focused on effect of soil degradation particularly in Rachuonyo North Sub-County and interrogated its potential in causing food insecurity situation in the area. The area was given attention because while her population is rapidly increasing in Homa Bay County (KNBS, 2019), there is no assurance that her soil 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 ATPs and apparently paradigm shift in land use-land cover systems in the area, the study is timely in addressing the risks imposed by such practices on food security situation in the area.

Smallholder farmers in Rachuonyo North-Sub-County have tracks-tracts? of land that when cultivated should produce adequate food, mainly maize and sorghum, in addition to groundnut, cassava, and sweet potatoes, for subsistence consumption. This is because the area experiences average temperature and moderate rainfall (Opere et al., 2016) which are perceived conducive for growing these crops. It is however common to find that most of these agricultural lands are uncultivated perennially while others are also characterized by wide and deep gullies. Additionally, food crops harvest particularly maize and sorghum last only between September and November, while the rest of the months are food insecure (Bay & Busia Counties, 2013; GoK, 2013 & GoK, 2017). 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 sufficiently agriculturally supportive as a result of soil degradation even in the face of shrinking food crop production, majorly maize and sorghum. What is evident is the increasing 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 yet we are aware that these are potential indicators of soil degradation. Regrettably, while soil degradation continues to accelerate alongside low food production in the study area, there is no academic attention that has interrogated the nexus between these phenomena and the ripple effect on food security. Studies including (Opere et al., 2016; Ajwang, 2017 & Keya, et al., 2019) are exclusively popularizing food insecurity as a consequence of factors like climate change and its variability, biodiversity integrity, water insecurity, pest and diseases and human health conditions such as effect of HIV/AIDS.

It is worth noting that within the context of sustainable land-use practices, the absence of sustainable ATPs relating to farming techniques, and proper soil utilization, is a threat in itself to soil security. This may go all the way to affecting agricultural production and by that an area is likely to face the risks of food insecurity. Therefore, this study sought to evaluate the effect of human-based soil degradation practices on food security in Rachuonyo North. The study aimed at providing insightful and appropriate findings for developing practical pathways to ensure that the food insecurity situation in the area is accurately perceived and addressed on a lasting basis. The absence of human knowledge,

especially among the rural population, about sustainable soil-use practices is central in limiting the level of agricultural output. Further, even when human adaptive measures such as irrigation, green house technologies, together with pest-disease control mechanisms can be employed to curb the effects of these threats, there is need for more attention to be given to soil security, to guarantee improved production (Ammari et al., 2015 & Adejumob et al., 2016). It is in this spirit that the study was anchored on the premise that all human-based agricultural and non-agricultural actions should enable soil security in all arable lands on a sustainable basis. According to Bagarello (2017), to achieve protection of soil against soil degradation, the establishment of how soil quality is lost by field-based practices in a place at a given time interval is fundamentally required. This invites the need to implement effective and economically sustainable land-use which according to Ocelli *et al.*, (2021) is one of the important actions to take and largely achievable when household heads, taking agricultural decisions, have the requisite practical knowledge about the consequences of their preferred soil and land utilization. By so doing (Lal, 2012; Al-Kaisi & Lal, 2017 & Indoria et al., 2017) argue that sustainable governance of soil resources will be realized.

With principal theory of praxeology in mind, the study considered human action or practice which emphasizes on knowledge to serve human well-being to ensure self-fulfilment (Caldwel, 1984 & Hieber, 2017), relevant and realistic. 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. The praxeological 'practices' refers to demonstrative knowledge while this knowledge implies learning as a consequence of action contrary to psychological 'actions' which is an aftermath of learning (Caldwel, 1984 & Defoer, 2000). The main proponent of this theory, Mises Von Ludwig, in 1946, contextualized praxeological thinking to establish the gravity of human choices in both economic and social sciences (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. Therefore, 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 likely to impose food insecurity situation. It is as a result of this chain of consequences that provide learning opportunity for human being to re-direct the energy towards adopting alternative and appropriate soil management and conservation strategies including but not restricted to organic farming.

Methodology

Cross-sectional survey design was used to explore the relationship between anthropogenic causes of soil degradation and food security. Both quantitative and qualitative data were collected. Qualitative data were used to examine both the level of anthropogenic-based causes of soil degradation as well as food security situation in the area while quantitative data aided in acquiring, testing and reporting statistical significance through a null hypothesis. The study was conducted in Rachuonyo North Sub-County in Homa-Bay County, which has seven wards; 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 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.

Figure 1: *Map of Rachuonyo North Sub – County showing Administrative unit*
Source*: Author (2023)*

The study population was 32,500 households (KNBS, 2019) drawn from West Karachuonyo, Kibiri, Kanyaluo and Kendu- Bay Town wards. 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). The four wards were purposively selected from the seven wards in the area of study based on the intensity of soil degradation (GoK, 2013 & GoK, 2017) while Cochran formulae (1977) was used to obtain a sample size of 289 respondents. 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. 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. The data was collected by use of; structured questionnaire, observation schedule that were moderated with the help of our 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.

Data analyses involved 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 SPSS, version 25.0. Significant testing was done using Binary Logistic Regression Model (BLRM) to establish the relationship between anthropogenic soil degradation practices and food security at 95% CL. The mathematical representation of the model is illustrated as follows;

$$P/_{1-P}(X^*) = B_0 + B_1 s_1 + B_2 sn_2 + B_3 t^h c_1 + B_4 lr_i + B_5 b^t c + B_6 m_1 + B_7 m^c$$

This model describes the probability of an event occurring as a function of *X* variables in such a manner that, $P/_{1-P}(X^*)$ 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 were the perceived human-based soil degradation practices denoted as $s_1 + sn_2 + t^h c_1 + lr_i + b^t c + m_1 + m^c$ used to predict $P/_{1-P}(X^*)$, that is, the probability that they affect food security situation with respect to regression coefficient $B_0+B_1+B_2+B_3\ldots+B_7$ such that;

s_1 = intensive sand harvesting; sn_2= intensive stone mining

$t^h c_1$= tractor cultivation (convectional tillage).

lr_i = intensive livestock rearing

$b^t c$ = bush and tree clearing

m_1= intensive hill slope settlement and cultivation

m^c = maize and sorghum cultivation.

Concerning measurement of food security situation, while food security can be measured at five different levels; individual, household, national, regional and global levels (FAO, 2013), the study considered its measurement at household level. There are forward-looking potential indigestible indicators at this level including; amount of food available, depending on the opinion of the households and prices of foodstuff. There is also 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 examinable coping strategies included school absenteeism, domestic violence, and dependence on relief food. For instance, relief food programs in schools is a tool in food scarcity-based environments 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). (Marques, 2003; FAO, 2019 & Mutea et al., 2022) categorize these food insecurity indicators as economic shocks. Economic shocks in the spirit 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 secure life (Mutea et al., 2022).

Results and discussions

The study considered 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

could help in understanding the variation in responses among the respondents. The findings showed that 50.2% of the respondents were male while 49.8% were female and this was an equal gender representation. 54.0% of the respondents were between 40-79 years of age while 29.8% had stayed in the area between 16-25 years. Regarding the level of education, majority, 50.2%, had primary as their highest level of education. 77.2% reportedly had monthly income below Ksh. 10, 000 as unemployment level was at 85.1%. Lastly, 39.1% had family sizes between 7-10 members which indicate large family sizes among the households.

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

The findings on the most common anthropogenic activities causing soil degradation in the area showed that 85.1% of the respondents viewed soil degradation as a consequence of clearing vegetation with majority of them, 80.3%, agreeing that this had 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. For instance, during Focused Group Discussion in Kanyaluo Ward (FGD2), one of the participants said that;

"Trees are largely cut for commercial consumption such as charcoal burning, construction, and firewood hence exposing this soil to erosion".

Further, while 96.2% of the respondents indicated that continuous cultivation of crops such as maize and sorghum has resulted to soil degradation, 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.

Averagely, majority of the households, 70.7% (Table 1) 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. Additionally, photographs taken (Plate 1) also revealed how agricultural lands are progressively turning into quarries together with expansion of derelict lands due to stone mining.

Table 1: *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/Average	**205**	**70.7**	**84**	**29.07**

Plate 1: *Stone mining from cultivatable land in West Karachuonyo ward*

From these findings, it is evident that the overall level of soil degradation in the the study area is higher than the global degradation. Such soils, according to studies (Keyzer et al., 2011; Wambua et al., 2014; Tully et al., 2015; Zingore et al., 2015 & Chunyan et al., 2020) are less agriculturally viable which according to (Gowing, 2008; FAO, 2013; UNGA, 2013 & UNGA, 2014) is likely to cause food insecurity in an area. This could be the reason why considering the level of food security situation among the households, the findings established that 95.8% of the residents were food insecure.

As pointed out on household-based indicators of food insecurity situation, while majority of the respondents had a view that there is high cost of staple food crops particularly maize and sorghum, many also reported high expenditure on purchasing food. Majority of the household heads (Table 2) indicated that there was uncertain food frequency, high stress related to food accessibility, household low standard of living, and high cases of domestic violence while school absenteeism was slightly below 50%. Lastly, there was low monthly income as well as high cases of unemployment among the households.

Table 2: Indicators of food insecurity in the area of study

Indicators	***Agree***		***Disagree***	
	n	**%**	**n**	**%**
High food prices	282	97.6	7	2.4
Long meals frequency	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

Effect of anthropogenic soil degradation practices on food security in the study area

Concerning the relationship between different anthropogenic-soil degradation-practices and food security, results of the binary logistic regression analysis (Table 3) indicated that clearing vegetation 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. The findings show specific anthropogenic practices in Rachuonyo North Sub-County that have significant consequences on soil degradation, which in turn affects food security which differ from other studies that primarily link food insecurity to climate change and water security (Bay & Busia Counties, 2013; Ajwang, 2017 & Opere et al., 2017) but display close nexus with studies such as (Lal, 2007 & Gomiero, 2016) hence calling for the need to address soil degradation in the area

Table 3 Binary logistic regression model

Predictor variables	**B**	**S.E**	**Wald**	**df**	**Sig**	**Exp(B)**
Clearing vegetation	-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.

Conclusion and recommendation

The study concludes that several anthropogenic practices including monoculture and continuous cultivation (96.2%), tractor tillage (92.8%), livestock farming (85.8%), stone mining (83.8%), clearing vegetation (83.1%), hill slope-based farming and settlements (80.6%) as well as sand harvesting (76.2%) are prevalent in the study area

Regarding the effect 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.

The study recommends that the County Government of Homa-Bay should consider establishing the Ministry of Forestry and Forest Reserves to aid in forest recovery and intensify strategic tree planting in the area. Additionally, the county government in partnership with the national government should discourage 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. Further, appropriately erecting the cut-lines around Homa Hills, whose slopes extend to most parts of the area of study, beyond which human activities including settlement and cultivation should not be encouraged. Reviewing tractor cultivation as well as educating tractor users about the importance of varying tractor tillage to ensure minimal soil disturbance. Homa-Bay County Government through the county assembly should also come up with

land-use policies detailing zones allocated for both agricultural and non-agricultural activities.

Further, there should be increased household-based fruit trees growing such as thorn melon, guava trees, pawpaw trees, banana trees, and mangoes to provide an alternative income generating economic activity. This will discourage sand and stone mining which apparently are common practices in the area. Additionally, the households should maximize on rain waters storage which is essential for irrigating the planted trees including fruit trees especially during short rains. The study also recommends improving on farming-based extension services including; encouraging maximum retention of crop residues in the farms in grounded form, avoiding cultivation across the contours, adoption of mixed and rotational cropping aimed at maintaining soil security as well as recovering soil nutrients.

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