Subsistence Crop Farming Practices And Household Food Security Among Smallholder Farmers In Lm3 And Lm4 Agro-Ecological Zones Of Lower Nyakach, Kenya

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Abstract

Food security among smallholder farm households, particularly in semi arid and arid parts of the globe has remained ever elusive. Further, such farmers are resource-poor meaning they engage in mostly indigenous farming practices, which have exacerbated the problem as the soil fertility has dwindled due to land overuse over time hence reduced production of food. Subsistence crop farming has helped easen this burden of lack of food security. The study adopted proportionate stratified sampling technique to determine the number of households per cluster of LM3 and LM4 AEZs to be included in the study sample and purposive sampling technique to choose the households by pure chance. Practices that focused on soil health included use of inorganic fertilizers, herbicides, pesticides and organic matter improvement practices. These practices played an important role in sustaining food production through protecting crops from insects, diseases and pests. Practices that improved organic matter content and amelioration included use of organic manure, composting, mulching, landfill and application of crop residues to the soil. Other practices studied were water conservation practices such as drainage and irrigation, as well as soil conservation practices such as construction of anti-erosion hedges. The study ascertained that there were significant associations between some crop farming practices and food security. The researcher proceeded to predict and ascertain the individual relationships between each practice and household food security by conducting a bivariate analysis. The practices selected for the purpose of the study were inorganic fertilizer use, organic manure application, anti-erosion structures and irrigation because they were most applicable in the study area. A positive relationship occurred between food secure households and inorganic fertilizer use (p value=0.011), organic manure application (p value =0.000), and irrigation (p value =0.032). At 5% significance level, there was a strong positive correlation between use of organic manure and food security (P-value is 0.000). This suggests that the use of organic manure for improving soil fertility and productivity was very important because it resulted in increased food production hence food availability, accessibility, stability and utilization. The findings reinforce the calling for farmers not to rely exclusively on inorganic fertilizers because manure has greater potential of improving soil fertility and most importantly while sustainably preserving the soil minerals. Irrigation had a great potential to improve food security because of the less dependency on rain-fed food production, and given that the study area experienced drought more often than not, and that there was water from rivers Awach and Miriu as well as the Lake Victoria that the locals could source for irrigation. With irrigation, drought was not a problem because food was produced throughout the yearly cycle hence stability. Further, the results from Multiple Regression analysis showed a significant negative influence of inorganic fertilizer use (Logs of Odds 0.484) and organic manure use (Logs of Odds 0.788) on the likelihood of a household being food insecure at the 5% significance level.

Key Words: *Subsistence Crop farming practices, Household food security; Smallholder Farmers; LM3 AEZs; LM4 AEZs*

Introduction

Crop farming in LM3 and LM4 AEZs of Nyakach comprised farming of maize, sorghum, beans, green grams, kales (*sukuma wiki*). Subsistence farming was the dominant system of crop production. Cultivation was done mainly using hoe, oxen-drawn plough while a few farmers used tractor. Crop farming was characterized by low inputs hence yields and profit margins were below the optimum. Majority of the households were resource-poor hence they adopted multiple cropping systems as risk diversification strategy. Crop farming practices studied included soil enrichment practices, soil organic matter improvement practices, water conservation practices and soil conservation practices.

Methodology and Sampling Techniques

This study adopted proportionate stratified sampling and purposive sampling techniques. Stratified sampling technique was used to determine the proportions of each cluster of households to be included in the sample. Stratified sampling is used in heterogeneous populations to create homogeneous subsets that share similar characteristics. Since smallholder households in semi-arid agro-ecological zones of Nyakach are mutually and exclusively divided into LM3 and LM4 strata, it was necessary to determine the proportions of each cluster of LM3 and LM4 so as to capture the household characteristics of each stratum in the sample. This could only be guaranteed through stratified sampling. For each cluster under the two strata, the sub-sample size was determined as:

$$\textbf{Cluster sample size} = \left(\frac{\text{cluster population}}{\text{total population}}\right)\textbf{required sample size}$$

For instance, the sample size of Central Nyakach sub-stratum of LM3 was determined as:

$$\textbf{Central Nyakach} = \left(\frac{1091}{9331}\right) \times 384 = 45$$

The same procedure was followed for all the clusters and the weights were given in proportion to the size of stratum. Sample sizes shown in Table 3.1 were obtained. Stratified sampling ensured that the agro-ecological zones were divided into homogeneous strata, and each stratum was represented in the sample in proportions equivalent to its size in the target population, and that each subgroup characteristics were accounted for.

Total sample size for LM3 stratum was determined as:

Samples for (Central Nyakach+ Nyalunya+ East Nyakach+ Asao)

$= (45 + 56 + 59 + 32)$=192

Total sample size for LM4 stratum was determined as:

Samples for (Pap Onditi+North East Nyakach+Rangul+North Nyakach)

=$(51 + 55 + 32 + 54)$ =192

Once the size of each stratum was determined, the individual households for each agro-ecological zone were selected through a simple random procedure using a sample frame of households obtained from Nyakach Sub-County agricultural office. Simple random sampling is the selection of a group of subjects (a sample) from a larger group (a population) for a study. Each household was chosen entirely by chance and each member of the population had an equal and independent chance of being included in the sample. This equal and independent chances property ensured that the sample was random, and a fair representation of the population of households in the LM3 and LM4 agro-ecological zones of Nyakach with regard to agricultural practices and food security. The random selection was done using random numbers technique, from a sampling frame constructed from a list of households obtained from the sub-County agricultural office.

Purposive sampling technique was used to access other stakeholders in the agricultural sector that were not household heads. Purposive sampling was used in selecting the key informants who included the Sub-County Agricultural Officer, 3 Sub-County Agricultural Extension officers, 1 officer from the VI-Agroforestry project and 1 officer from the World Vision-Kenya (WVK), which are NGOs that had worked with the farming households on livelihood improvement and food security programs. Purposive sampling technique was also used for selection of community members for the Focus Group Discussions (FGDs). Members of the FGDs included men, women, youth and officers from the Sub-County Agriculture and Livestock office, Agricultural Extension Office, WVK and VI-Agroforestry. The key informants and members of FGDs identified using this technique provided focused information on crop farming in the study area and its influence on land use practices and food security.

Results

Soil enrichment practices

Practices that focused on soil health included use of inorganic fertilizers, herbicides, pesticides and organic matter improvement practices. These practices played an important role in protecting crops from insects, diseases, pests, and increased soil fertility. Table 1 shows that the level of use of each of the chemical products was still very low in the study area.

Table 1: Use of agrochemicals by percent adopters (N=384)

Product	Percent adopters of the products (%)

Inorganic fertilizer (Urea, CAN, DAP, MAP and NPK)	19
Herbicide (Gramoxone, Aurora turbo SG, Linagan 50 WP, Kalif 480 EC)	2
Pesticides (Insecticides e.g. furadan 5G, Acletic, Dipterex); Fungicides e.g. Dithane/Sancozab, Antracol, Ambush CY) and Chlorofenviphos	4

Source: Field data, 2022

Inorganic fertilizer was the most commonly used chemical product by a larger proportion of the respondents at 19%, pesticides were used by 4% of the respondents while herbicides was used by 2% of the households. The remaining 75% of households did not apply agro-chemicals on their farms. There were widespread attacks of stalk borer (*Buseola sp.* Lepidoptera), aphids (*Aphidae sp.* Homoptera), cutworm (*Agrotis sp*. Lepidoptera), termites and weeds on maize and sorghum crops and blights on bean crop. However, the households mostly applied pesticides on vegetables, water melon and rice crops under irrigation. The staples such as sorghum, beans, green gram and maize were least considered for pesticide application. As shown on the Table 2, households sourced agrochemicals from the private sector, farmers' cooperatives, open-air markets and extension services.

Table 2: Sources of inorganic fertilizer and pesticide supply by percent respondents (N=384)

Source of chemical products	Fertilizer (%)	Pesticide (%)
Private sector	1	1
Open air markets and input shops	35	75
Farmers' cooperatives	1	4
Extension services	11	4

Source; Field data, 2022

The open air markets and input shops was the major source of inorganic fertilizer for the respondents, with a proportion of 35% of the respondents buying fertilizer from these markets. A proportion of 11% of the respondents confirmed that they got fertilizer from extension services. Cooperatives and the private sector provided 1% of fertilizer to the respondents each, respectively. However, a proportion of 52% of the respondents did not use any of the given sources of inorganic fertilizers. Further, the source of pesticides were the local markets which was the most important source (75%) Extension services, cooperatives and farmers' associations were sources of 4%, 4% and 1% of pesticides used by the respondents, respectively.

Use of inorganic fertilizer

Table 3 illustrates that the factors that commonly influenced a household's adoption of use of any modern technology were: acreage owned; Extension services received; the number of trainings that a farmer engaged in; household head's access to credit facilities and the household head's belonging to a cooperative.

Table 3: Factors determining adoption of inorganic fertilizer use

Determinant factor	**B**	**S.E**	**Significance**	**Exp (B)**	**Lower**	**Upper**
Constant	-1.687	0.313	0.000	0.185		
Number of plots owned	0.154	0.040	0.000**	0.166	1.078	1.262
No. of visits per month by Extension officer	0.245	0.133	0.066*	1.277	0.984	1.659
Number of trainings per season	0.253	0.230	0.271	1.287	0.821	2.019
Access to credit (1)	0.114	0.380	0.765	1.120	0.532	2.359
Member of cooperative (1)	0.533	0.231	0.021**	1.704	1.084	2.680
Farm size (ha)	0.060	0.093	0.517	1.062	0.885	1.274

Chi-square value = 40.003; 95% Confidence. Interval for EXP (B); P value = 0

Source: Field data, 2022

The results of the binary logistic regression from Table 3 show that the total number of plots, the number of visits per month by extension workers and membership of farmers' to cooperatives influenced positively the use of inorganic fertilizer. A one unit increase in the number of visits per month by extension workers increased the log of the odds of fertilizer use by a factor of 0.245, all factors held constant. This is logical because knowledge exchange between extension workers and farmers on the one hand and sensitization about the benefit of using inorganic fertilizer for productivity growth on the other hand could help farmers to improve their way of combining assets to improve their methods of production including inorganic fertilizer use. Furthermore with extension workers' visits, farmers are exposed to information which reduces their subjective uncertainty and increases their chance of improved level of uptake of technologies, inorganic fertilizers included (Asiabaka, *et al*., 2001; Agwu, 2004).

Further, results on Table 3 show that the number of trainings attended by a farmer per season and farm size; had no statistically significant influence on the adoption of inorganic fertilizer at 10% significance level. Although it is a fact that the use of fertilizer requires capital, the results indicate that access to credit has no significant influence on the adoption of fertilizer-use in semi-arid Nyakach. This could be explained by the fact that only a few households had access to credit and therefore access to credit was not so determining a factor. Further, 98% of the households lacked the land titles or other acceptable security for collateral required by financing institutions. Another reason may be that the procedures for obtaining credit were too complicated and time consuming for household heads that needed credit.

In addition, the results from the analysis illustrate that household heads who were members of cooperatives are more likely to use inorganic fertilizer than non-members of cooperatives. This is probably due to the fact that farmers' cooperatives have more access to agricultural information and credit and therefore their members have a better ability to adopt innovations, inorganic fertilizer-use included, than non-members of cooperatives. Bahiigwa (2002) and Clover (2003) agree that when it comes to agricultural support provision, farmers' cooperatives reduce the transaction costs and have high potential to remedy on the issue of imperfect information and uncertainty of agricultural inputs. In addition, the total farm size had a significant positive influence on the use of inorganic fertilizer whereby households having larger farm sizes were more likely to use inorganic fertilizer than households with smaller farms.

Analyses of the results indicate that the model chi-square is 40.003 with a p-value of 0.000. This indicates that the model is significant, that there is a significant relationship between inorganic fertilizer use and the set of dependent variables of food availability, access, utilization and stability. The Cox & Snell R^2 for the model is 0.108 and the Nagelkerke R^2 is 0.144 which show that there is some association between the dependent and independent variables. The Hosmer and Lemeshow, which is the goodness-of-fit measure had a value of 7.138 and P-value of 0.522 which means that the predicted values are not significantly different from the observed values.

From the Table 3, the model used was:

$$\text{Logit}(p) = \log\left(\frac{p}{1-p}\right) = Z = -1.687 - 0.154*X^1 + 0.245*X^2 + 0.253*X^3 + 0.114*X^4 + 0.533*X^5 + 0.060*X^6$$

Where: X^1 = total no. of plots; X^2 = No. of visits per month by extension workers; X^3 = No. of trainings attended per season; X^4 = Access to credit; X^5 = member of cooperative, X^6 = farm size (ha)

The following equation estimates the odds: $\frac{P}{1-P} = e^{Z}$

Finally, the probability of inorganic fertilizer adoption (p) is obtained by applying the logistic transformation: $P = \frac{e^{Z}}{1+e^{Z}}$

Figure 1 illustrates that the probability of inorganic fertilizer use increased by a factor of 0.14 when the household head was a member of cooperative compared to the reference. This probability increased by a factor of 0.04 when the size of farm increased by one unit and by a factor of 0.03 when the number of visits increased by one unit.

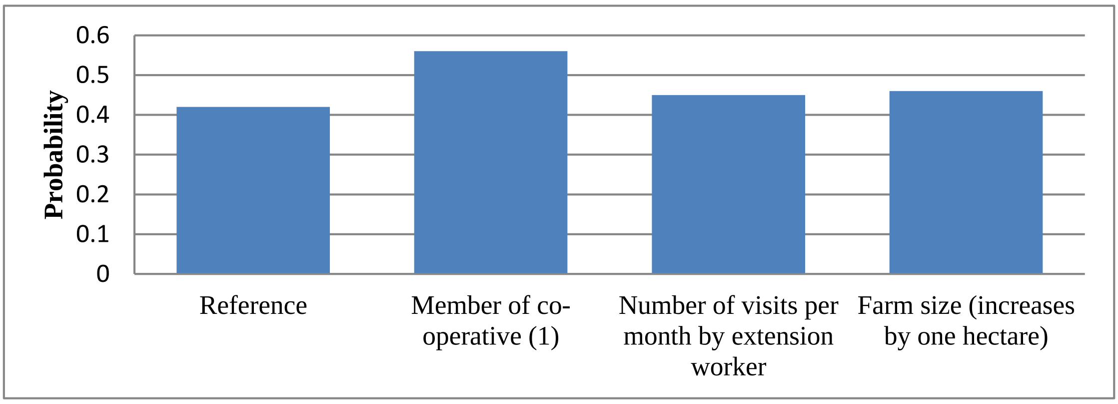

Figure 1: Single bar graph showing the Probability of household use of inorganic fertilizer by access to information and farm size
Source: Field data, 2022

The results of this analysis concludes that membership to cooperatives; number of visits per month by extension workers and the size of farm per household are major factors determining inorganic fertilizer use in Nyakach sub-County. This result concurs with the findings of Morris, *et al*. (2007) and that exchange between extension workers and farmers and sensitization about the benefit of inorganic fertilizer use for improved productivity could help farmers to improve their way of combining assets to improve their methods of production including inorganic fertilizer use. Further, Cavane (2009) intimates that extension officers' visits enlighten farmers and reduces their subjective uncertainties thus increases adoption rate of modern technologies including fertilizers application. Results in Table 4 show the influence of inorganic fertilizer on crop yield by comparing the mean crop yield of the main food crops among users and non-users of the practice.

Table 4: Crop yield by users and non-users of inorganic fertilizer

	Users (n=173)		Non-users (n=211)			
Mean crop yield	Mean	SD	Mean	SD	t-test	P-value
Rice	92.8	188.5	68.6	196.2	-1.2	0.236
Maize	92.8	197.6	32.2	71.6	-3.7	0.000
Beans	195.3	200.1	115	155.8	-4.1	0.000
Sorghum	175.1	364	61.3	187.2	-3.6	0.000

Source: Field data, 2022

Table 4 further shows the results of t-test which provide evidence that there is no statistically significant difference in mean production of rice between inorganic fertilizer users and non-users (p-value of 0.236). However, there is a statistically significant difference between fertilizer users and non-users in mean production of Maize, beans and sorghum, which all have p-values of 0.000. This is an indication that inorganic fertilizer use led to increased production of maize, beans and sorghum hence increase in food availability among households.

This result agrees with the findings of Mwangi (2000) and FAO (2008) that the positive effect of crop farming on food production requires intensive agriculture based on modern technologies due to shortage of land.

Soil organic matter improvement practices

Practices that improved organic matter content and amelioration included use of organic manure, composting, mulching, landfill and application of crop residues to the soil (Table 5).

Table 5: Soil organic matter improvement practices by adopters (N=384)

Soil organic matter improvement practice	Percent Adopters of the practice
Organic manure	62
Composting	71
Mulching	76
Landfill	92
Application of crop residues	23

Source: Field data, 2022

As indicated on Table 5, most (92%) of respondents affirmed the use of landfill practices, followed by mulching with 76% of the respondents. Composting and organic manure were also used by 71% and 62% of households respectively. Application of crop residues to the soil was however low at 23% because most farmers fed the residues to livestock. If the use of organic soil fertility management practices is compared with the chemical fertilizer (46%) it is evident that the uptake is much higher for the use of organic manure than the uptake of chemical fertilizer use. A possible reason for preferring manure over chemical fertilizers is its lower cost.

Further, results in Table 6 shows the influence of manure on crop yield by comparing the mean crop yield of the main food crops among users and non-users of the practice.

Table 6: Crop yield by users and non-users organic manure

	Users of manure (n=238)		Non-users of manure (n=146)			
Mean yield	Mean	SD	Mean	SD	t-test	P-value
Rice	111.6	229.2	27.9	89.2	-4.8	0.000
Maize	76.6	173.3	33.3	82.6	-3.1	0.002
Beans	181	185.5	106.2	165.8	-3.9	0.000
Sorghum	160	338.9	38.5	149.5	-4.6	0.000

Source: Field data, 2022

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Results in Table 6 show that there is a statistically significant difference in mean production of rice, maize, beans, and sorghum between users and non-users of organic manure. For all crops the mean production was higher for organic manure users compared to non-users. This shows that when the farmers used manure then household food availability increased. This is interpreted that manure use increased yields of rice, maize, beans and sorghum thus increasing household food availability. These results are in support of findings of FAO (2006) that organic matter improves the soil structure, diminishes soil erosion, and helps to accumulate moisture, and that manure use contributes to releasing nutrients to the soil slowly and helps to make organic matter with long -term benefits (Place, *et al*., 2003).

Water conservation practices

a) Marshland improvement practices

Drainage was the most widely adopted marshland improvement practice in the study area, adopted by 78%of households. This was because semi-arid Nyakach is located on a flat terrain and dominated by vertisols, which is poorly drained. Hard pan had mostly formed at 0.5 feet below the ground surface and this impeded water penetration and retention capacity of the soil.

These conditions exposed the study area to perennial flooding during rainy seasons that necessitated digging water channels, constructing dykes, building gabions and digging rills in homesteads and farmlands that lead water out. Also, drainage was a simple practice of regulating the water flow on farmland and was done by the active household members including children without necessitating paid labor. However, irrigation practices were not well adopted by the respondents, as about 9% of the respondents residing in Gem Rae, Gem Nam and Agoro West sub locations, near River Awach had adopted irrigation. These farmers practiced small scale traditional ways of abstracting water from the rivers using portable pipes and buckets for irrigation of vegetables and water melon. About 8% of households produced rice under irrigation at the local small-scale Gem-Nam irrigation project.

b) **Irrigation**

Table 7 illustrates the influence of irrigation on food security as was examined by comparing mean production of selected food crops between adopters and non-adopters of the practice Irrigation. Irrigation was practiced mainly on the wetlands for rice production. However, a few households near river Awach and Lake Victoria irrigated other crops such as maize, water melon and vegetables based on affordability of the practice.

Table 7: Crop yield by users and non-users of irrigation

	Adopters of irrigation (n=34)		Non adopters of irrigation (n=350)			
Mean crop yield (tons)	Mean	SD	Mean	SD	t-test	P-value
Rice	147.3	251.3	73.2	185.3	-2.0	0.038
Maize	137.6	304.5	52.5	119.5	1.5	0.127
Beans	181.2	182.1	149.7	181.7	-0.9	0.351
Sorghum	181.4	314.8	107.1	285	-1.3	0.164

Source: Field data, 2022

Table 7 shows that a dismal 8.9% of the respondents practiced irrigation while 91.1% had not adopted the practice. This low adoption of irrigation could be as a result of the cost involved or ignorance. Further, the results illustrate that there was significant difference in yields of rice and no significant difference in yields of maize, beans and sorghum between adopters and non-adopters of irrigation. This can be explained by the fact that rice was the only food crop mostly produced under irrigation in the study area. This finding explains the dismal performance of crops in semi-arid Nyakach and agrees with Dabour (2002) that irrigated agriculture is attributed to be of greater importance in increasing food production in semi-arid lands of the sub-Saharan Africa than rain-fed agriculture. It should be noted that whereas the study area experienced low and unreliable rainfall, farmers greatly depended on rain-fed agriculture, with irrigation being adopted by 8.9% of households. It is worthy to note that this low adoption of irrigation in the semi-arid environment, therefore, could have resulted in low crop yields experienced hence reduced household food security.

Table 7 further illustrates that there was a statistically significant difference in mean production for rice between adopters and non-adopters of irrigation. Nevertheless there is no statistically significant difference in mean production of maize, beans and sorghum between adopters and non-adopters of irrigation. The lack of significance for other crops other than rice can be explained by the fact that irrigation was practiced on wetland and in most cases rice is the only food crop under study that was produced under irrigation. This finding agrees with Dabour (2002) that irrigated agriculture is of importance in increasing food production in semi-arid lands of the sub-Saharan Africa than rain-fed agriculture. It should be noted that whereas the study area experienced low and unreliable rainfall, farmers greatly depended on rain-fed agriculture, with irrigation being adopted by 8.9% of households. It is worthy to note that this low adoption of irrigation in the semi-arid environment, therefore, could have resulted in low crop yields experienced hence reduced household food security.

Soil conservation practices

a) Anti-erosion hedges

Table 8 indicates that the total acreage owned by household; extension services received; the number of trainings that a household head engaged in; farmer's access to credit facilities and the farmer's belonging to a cooperative were chosen by the study as possible factors that influenced household's adoption of anti-erosion hedges. These factors were selected because trainings were conducted by extension officers, World Vision-Kenya and Vi-Agroforestry project on erosion control measures; there were two cooperative organizations dealing with rice production and households had varied sizes of land for agricultural production.

Table 8: Factors determining adoption of anti-erosion hedges

Determinant factor	B	SD	Sig.	EXP(B)	Lower	Upper
Constant	-1.568	0.335	0	0.208		
No. of visits per month by extension Officer	0.24	0.127	0.059**	1.272	0.991	1.631
Number of trainings per season	0.248	0.215	0.248	1.281	0.842	1.951
Member of cooperative (1)	0.52	0.231	0.025**	1.682	1.069	2.646
Household size	0.095	0.053	0.072*	1.099	0.999	1.219
Farm size	1.188	0.091	0.038**	1.206	1.01	1.441

Significance level: ** = 0.05 significance level; 95% C.I for EXP (B); Chi-square = 28.761; P value= 0

Source: Field data, 2022

Binary logistic regression results presented in Table 8 show that the numbers of visits per month by extension workers; household head being a member of a cooperative; household size and farm size had a significant positive influence on the adoption of anti-erosion hedges. Hence household heads who were members of cooperatives were more likely to adopt anti-erosion hedges compared to those that were not members of cooperatives. This implies that cooperatives and extension services provided necessary technical information and benefits of anti-erosion hedges, a fact that may have reduced farmers' resistance to change and resulted in increased adoption rate of the practice. Further, the results indicate that larger households are more likely to adopt anti-erosion hedges. In addition, a one unit (ha) increase in the farm size increases the log of the odds of adopting anti-erosion by a factor of 1.188, keeping other variables constant. This can be understood that if one extra hectare of land is available, a household is likely to adopt anti-erosion hedges because in that case the household does not fear competition for land between crops and the anti-erosion hedges. Also, ownership of a larger farm size is likely to result in tenure security which may cause the owner to invest on his/her farmland through various ways including anti-erosion hedgerows so as to ensure sustainable crop production. However, there is no significant influence of the number of trainings attended by farmers per season on the adoption of anti-erosion hedges.

Analyses were done on the data in Table 8 and the results showed that the model chi-square is 28.761 with a P-value of 0.000. This indicates that the model is significant, that variables in the model other than the intercept are useful in explaining anti-erosion adoption. The Cox & Snell R^2 for the model is 0.079 and the Nagelkerke R^2 is 0.107 which leads us to believe that there is at least some association between the dependent and independent variables .The goodness-of-fit measure (Hosmer and Lemeshow) has a value of 11.046 and P-value of 0.199 which means that the predicted values are not significantly different from the observed values.

Further, Figure 2 illustrates that the probability of adopting anti-erosion hedges increases by a factor of 0.12 when the household head is a member of cooperative compared to if the household head is not a member of any cooperative. When the number of visits per month by extension workers increased by one unit, the probability of farmers adopting anti-erosion hedges increased by a factor of 0.02. At the same time a one unit increase in farm size increased the probability of adopting the use of anti-erosion hedges by a factor of 0.24. Reference is a situation when the household head is not a member of a cooperative is not visited by extension worker and has a farm size of 0.99 hectares which is the average household farm size in the study area.

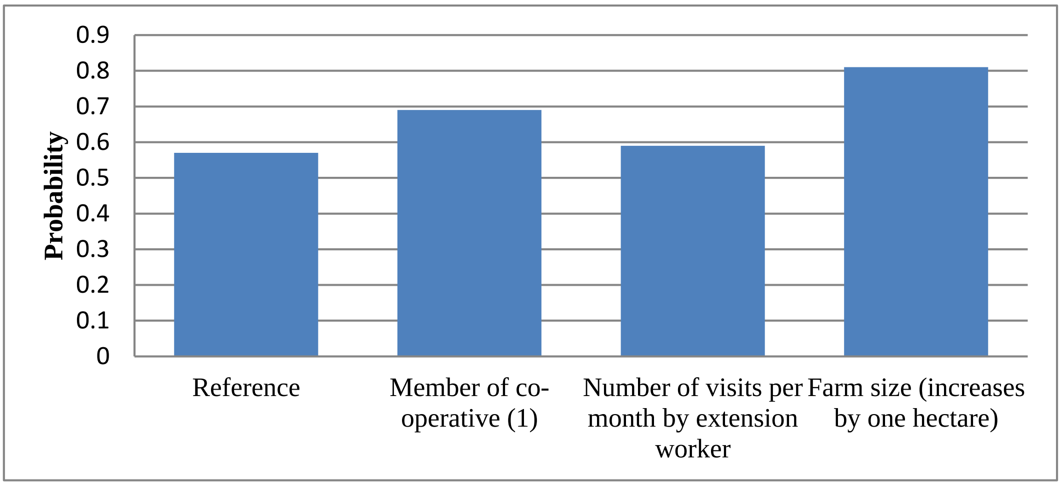

Figure 2: Probability of Household adoption of anti-erosion hedges
Source: Field data, 2022

Also, discussions with FGDs indicated that anti-erosion hedges contributed to the protection of soil against erosion especially in the areas of flat topography prone to flooding during rainy seasons. The importance of anti-erosion hedges is shown by comparing the mean production of selected crops between adopters and non-adopters as presented. Results show that 60.9% of the respondents constructed anti-erosion hedges while 39.1% did not adopt the practice.

Table 9: Crop yield by users and non-users of anti-erosion hedges

	Adopters of anti-erosion hedges (n=150)		Non adopters of anti-erosion hedges (n=234)			
Mean crop yield (tons)	Mean	SD	Mean	SD	t-test	P-value
Rice	108.9	247.3	61	145	-2.1	0.038
Maize	80.5	175.7	47	123.7	-1.9	0.005
Beans	189.9	194.5	128	169.1	-3.1	0.002
Sorghum	124.8	236.1	106.6	317.3	-0.5	0.561

Source: Field data, 2022

The results of t-test in Table 9 show that there is no statistically significant difference between harvests of adopters and non-adopters of anti-erosion hedges in mean production of sorghum, which is an indigenous crop of the study area. Results show that 39.1% of the respondents constructed anti-erosion hedges while 60.9% did not adopt the practice. Probably, the low level of adoption could be due to lack of awareness of the importance of anti-erosion hedges in improving soil conservation. Further, t-test results showed that there was no significant difference in mean production of sorghum (indigenous) but there was a significant difference in mean production of rice, maize, and beans between adopters and non-adopters of anti-erosion hedges. This indicates that the practice had a positive influence on food production of rice, maize and beans (exotic) in the semi-arid Nyakach.

This finding confirms to the households in the study area, that indigenous crops are still the key to sustainable crop production. This result supports the findings of Obuoyo (2005) and McIntyre, *et al* (2009) that communities of dry lands should revert to growing traditional crops so as to ensure food security, a fact they attribute to the weather and edaphic conditions of these geographical areas. It is however difficult to compare productivity among adopters and non-adopters of the above practices because with a mixed cropping system, it is difficult to know how much hectares of each crop are planted per season.

Bivariate Relationship between crop farming practices and food security

Having ascertained that there are significant associations between some crop farming practices and food security in semi-arid agro-ecological zones of Nyakach, the researcher proceeded to predict and ascertain the individual relationships between each practice and household food security by conducting a bivariate analysis. The practices selected for the purpose of the study were inorganic fertilizer use, organic manure application, anti-erosion structures and irrigation because they were most applicable in the study area as presented in Table 10.

Table 10: Bivariate relationship between crop farming practices and food security

Food secure	Use of inorganic fertilizer	Use of organic manure	Anti- erosion hedges	Irrigation

	No	Yes	Total	No	Yes	Total	No	Yes	Total	No	Yes	Total
No respondents	195	154	349	143	206	349	213	136	349	321	28	349
(%)	56	44	100	41	59	100	61	39	100	92	8	100
Yes respondents	18	37	55	3	52	55	30	25	55	45	10	55
(%)	32	68	100	6	94	100	55	45	100	81	19	100
Total respondents	207	177	384	146	238	384	234	150	384	349	35	384
(%)	54	46	100	38	62	100	61	39	100	91	9	100
	Chi-square=6.387 P-value=0.011			Chi-square=4.372 P-value=0.000			Chi-square=0.512 P-value=0.474			Chi-square=4.588 P-value=0.032		

Source: Field data, 2022

Table 10 shows the relationship between selected crop farming practices and food security. In each case the first row is the number of respondents and the second row are percentages of respondents engaging in the various crop farming practices and their household food security status. A positive relationship occurred between food secure households and inorganic fertilizer use, organic manure application, and irrigation. At 5% significance level, there is a strong positive correlation between use of organic manure and food security as the P-value is 0.000. This suggests that the use of organic manure for improving soil fertility and productivity is very important because it results in increased food production hence availability. The findings reinforce the calling for farmers not to rely exclusively on inorganic fertilizers because manure has greater potential of improving soil fertility and most importantly while sustainably preserving the soil minerals. This view is in agreement with FAO (2008; 2015b) that the application of manure contributes to the supply of plant nutrient and replenishes soil organic matter sustainably.

Similar significance was found with irrigation at P-value of 0.032. Even though not adopted by many farmers because of the high cost factor, irrigation has a great potential to improve food security because of the less dependency on rain-fed food production, and given that the study area experiences drought more often than not, and that there are water rivers and the Lake Victoria that the locals could source water for irrigation. With irrigation, drought is not a problem and hence food is produced throughout the whole yearly cycle.

Multivariate Relationship between crop farming practices and food security

Having determined the relationships between each crop farming practice and food security, the researcher investigated the relationships between all the practices taken together and household food security. This was necessary since the practices were presumed to influence food security, and as already suggested in literature, it is not possible that each practice could influence food security in isolation. This being a social study, and crop farming practices being social variables in social arena, there was high possibility that the crop farming practices could have a combined influence on food security, and it was necessary to establish the extent to which this was true hence the need for a multiple relationship between all the practices and food security. Hence Multivariate analysis was conducted to examine the relationship between several independent variables simultaneously and food security. Table 11 shows the practices that were analyzed by this study as: use of inorganic fertilizer, use of manure, composting, mulching, irrigation, use of anti-erosion hedges and farm size.

Table 11: Multivariate relationship between crop farming practices and food security

Crop farming practices	B	SD	Significance	Exp (B)	Lower	Upper
Constant	1.592	0.444	0	4.912	-	-
Use of inorganic fertilizer	-0.484	0.243	0.047**	0.616	0.383	0.993
Use of manure	-0.788	0.274	0.004**	0.455	0.266	0.778
Composting	-0.217	0.327	0.507	0.805	0.425	1.527
Mulching	-0.311	0.284	0.274	1.364	0.782	2.378
Irrigation	-0.472	0.400	0.238	0.624	0.285	1.366
Anti-erosion hedges	0.075	0.250	0.763	1.078	0.661	1.759
Farm size (ha)	-0.347	0.117	0.003**	0.707	0.562	0.889

** Significance level=0.05; 95% Confidence Interval; chi-square value=47.769; P-value= 0
Source: Field data, 2022

Regression results on Table 11 reveal that there is no statistically significant influence of individual practices such as mulching, composting, irrigation of marshland, and anti-erosion hedges on severe food insecurity in semi-arid Nyakach at 5% significance level. Checking for multicollinearity the results revealed that there is a weak correlation between different crop farming practices and food security. Further, the results from Multiple Regression analysis show a significant negative influence of inorganic fertilizer use and organic manure use on the likelihood of a household being food insecure at the 5% significance level. The log of the odds of being food insecure decreased by a factor of 0.484 when households used inorganic fertilizer compared to households that did not use inorganic fertilizer, all factors held constant.

Similar result is observed in the case of organic manure application where the log of the odds of being severely food insecure decreased by a factor of 0.788 when households used organic manure compared to households not using manure, all factors held constant. This means that households that used organic manure were less likely to be food insecure than households that did not use manure. The results show also that households with a smaller farm size were more likely to be food insecure compared to households with larger farm size.

This is confirmed by statistically significant negative coefficient of the variable which shows that for a one unit (ha) increase in farm size, the log of the odds of being food insecure decreased by a factor of 0.347, all factors held constant. In the study area the average farm size is shrinking and the land: man ratio is reducing as population growth continues to increase. This may result in reduced farm yield, income and expenditure levels which in turn will worsen the food status of the households leading to food insecurity.

The results in Table 11 also show that the model chi-square is 47.769 with a p-value of 0.000. This indicates that the model is significant, that variables in the model other than the intercept are useful in explaining severe food insecurity. The Cox & Snell R^2 for the model is 0.125 which leads us to believe that there is some association between the dependent and independent variables. Figure 5.5 shows the probability of a household being food insecure by use of soil fertility improvement practices and size of household farm.

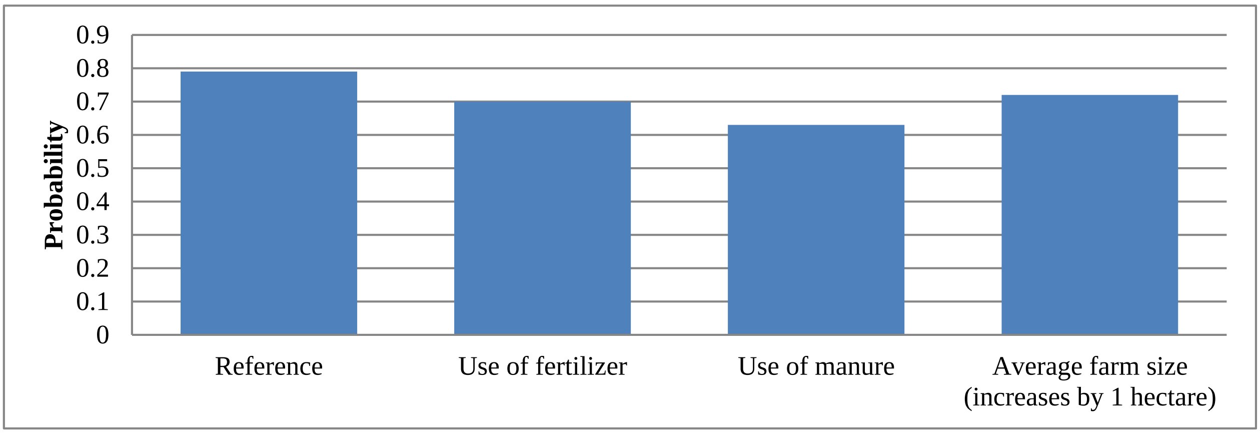

Figure 3: Single bar graph of Probability of household food security by farming practices
Source: Field data, 2022

Results in Figure 3.show that the probability of a household being food insecure when inorganic fertilizer is used drops by 0.09 compared to the reference value while this probability drops by 0.16 when organic manure is used compared to the reference. In addition, a one unit (ha) increase in farm size decreases the probability of a household being food insecure by a factor of 0.07 compared to the reference value. The reference represents a situation when a household does not use inorganic fertilizer, does not use manure and has an average farm size of 0.99 hectares. It is worthy to note that the results from this analysis show that the use of inorganic fertilizer, use of organic manure and size of farm are major determinants of food security in the study area. The study establishes that the probability of a household being food insecure decreases with the use of inorganic fertilizer; use of organic manure and an increase in farm size.

These results agree with Faridi and Wadood (2010) and Feleke, *et al*. (2005) that crop farming practices influence household food security. Further, Bogale and Shimelis (2009) noted that the positive influence of crop farming on food production requires intensive agriculture based on modern and sustainable practices because land owned by households are decreasing due to increase in human population (Omotesho, *et al*. (2010) and consequent overuse of agricultural land (Faridi and Wodood, 2010)

Conclusion

Crop farming practices investigated by the study are found to be significant determinants of household food security in semi-arid agro-ecological zones of Lower Nyakach Sub-County, both individually and collectively. These practices were: soil organic matter improvement practices such as use of inorganic fertilizer, organic fertilizer, mulching and composting; water conservation practices such as irrigation; agroforestry practices and soil conservation practices. There was a strong correlation between food security and use of manure, fertilizer and irrigation as their P-values were 0.000, 0.011 and 0.032, respectively. This suggests that the use of manure is better than use of fertilizer for improving soil fertility and productivity, but they are both very important because they both had significant positive influence on the likelihood of a household being food secure. The findings reinforce the calling for farmers not to rely exclusively on chemical fertilizers because manure has better potential of improving soil fertility and most importantly while sustainably preserving the soil minerals. Further, it is evident that even though irrigation was not adopted by many farmers, it has a great potential to improve household food security.

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