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Determinants of household food and nutrition security among the dairy farmers in Machakos and Kirinyaga Counties, Kenya

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Abstract (189 words)

Food security is a global challenge and its measurement is hampered by among other things the high cost of data collection and lack of simplified models. This study adopted the household dietary diversity (HDDS) and food consumption score (FCS) which are qualitative tools and are effective in ascertaining household food status. Data was collected from 629 farming households; 313 in Kirinyaga County and 316 in Machakos County. An ordered logit model was used to assess the determinants of the household food security elements. Age of the household head, household income, off-farm income ranks, perception of food shortage, and extension access were the positive determinants for HDDS; while gross income, expenditure, and crop ranks were the positive determinants for FCS. Distance to the market and number of months of food shortage were inversely related to HDDS and FCS. The findings provide useful baseline information specifically targeting possible solutions to attainment of food security. The findings can also be used in assisting households to diversify their income sources, improve their food diversity as well as the frequency of consuming certain food groups hence contribute to improvement in food and nutrition security.

Key words: Food Security, Ordered Logit, Dairy farmers

1.0. Introduction

Globally, food security has been a topic of major concern to many research and development organizations each trying to assess the status and identifying solutions to this chronic problem. In order to come up with policies that can accelerate attainment of food security, policy makers are seeking measurement methods that are simple, easy to use and interpret (Kennedy, 2002). In addition, it is important to understand the factors that influence attainment of food security in order

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to target specific aspects that offer solutions. World over, proper nutrition and high diet quality is associated with eating a wide variety of food types, and households that are able to access quantity and safe food throughout the year are said to be economically viable and food secure. World Bank (1986) defined food security as access by all people at all times to enough food for an active healthy life. This definition was further improved by FAO (1996) by encompassing nutritionally adequate safe and preferred food. Challenges are however experienced in measurement of food security especially because of the high cost of collecting quantitative data. With such limited options, many organizations opt for qualitative methods such as household dietary diversity score (HDDS) and food consumption scores (FCS) since the information required to calculate the two food security measures is less costly and less time consuming (FAO, 2010; FAO, 2011; WFP, 2007, 2008). HDDS was first used by Food and Agricultural Organization (FAO) using the guidelines provided by Food and Nutrition Technical Assistant Project (FANTA) while FCS was adapted and first used by World Food Programme (WFP) by assigning weights to specific food groups. Both FCS and HDDS have been validated in different countries as proxies of household per capita energy intake and have been identified to be important indicators for monitoring and surveillance of household access to food (Otilia *et al*., 2017).

HDDS a simple count of food groups that a household has consumed over the preceding 24 hours and is an important indicator for food security as more diversified household diet is correlated with caloric and protein adequacy (Swindale and Bilinsky, 2006). It provides a snapshot of a household's ability to access food as well as its socioeconomic status (Kennedy *et al*., 2011**)**. On the other hand, FCS combines dietary diversity and food frequency applying a weighting system. It is a composite score based on dietary diversity, food frequency, relative nutritional importance of different food groups and also serves as a proxy for current food security. The two measures have been used to identify the households' food deficiencies or excesses and also as a baseline to implement interventions that improve households food consumption.

While these two methods have been found to be very attractive measures of food security, most of the studies conducted only end at estimating the scores using simple counts (for HDDS) and weighted sum (for the FCS). However, literature on more advance analysis on their determinants is scanty or does not exist. This type of information is critical in identifying the specific factors that influence or hinder attainment of food security at household level. Identifying and estimating such determinants can be helpful in coming up with specific solutions for addressing food insecurity. This paper presents results on econometric analysis of the determinants of HDDS and FCS using data collected from dairy from Kirinyaga and Machakos counties, Kenya to identify the factors that either influence or hinder realization of food security at household level.

2.0. Methodology

Study sites

The survey was conducted in Kirinyaga and Machakos (Kangundo-sub County) counties. Machakos has a unique physical and topographical feature with an altitude which rises from 790 metres to 1594 metres above sea level. Rainfall is well distributed ranging from 500 mm – 1,300 mm per annum and the temperature range from 18° C to 29° C. The soils are well-drained, shallow dark-red clay and the vegetation depends on the altitude. Kirinyaga County has an altiyute that rises from 1155 m – 5380m above sea level, it has tropical climate and equatorial rainfall pattern

averaging 2146 mm per annum for long rains and 1,212 mm per annum for short rains and the temperature range from 18˚C to 29˚C.
A total of 313 and 316 farming households were interviewed in Kirinyaga and in Machakos County respectively. The survey data were summarized and descriptive data analysis conducted including means, frequencies and inferences using chi square and F-statistic.

To calculate the HDDS, summation was done for the 12 food groups which a households had consumed in a period of 24 hours. HDDS ranged from 0-12 and or this study, it was ranked accordingly into low dietary diversity (0-3), medium dietary diversity (4-6) and high dietary diversity (7-12). The twelve (12) food groups included were: cereals, roots and tubers, vegetables, fruits, meat/poultry/offal, eggs, fish and sea foods, legumes/nuts/seeds, milk and milk products, oils and fat, sugar/honey, condiments/beverages (FAO, 2011). FCS was calculated by first re-grouping the 12 food groups to eight (Table 1) and thereafter multiplying by a given weight (WFP, 2008) and the number of days that food type was consumed in a period of 7 days as follows;

$FCS = (4 \times meats) + (2 \times staples\text{-}cereals) + (3 \times pulses) + (1 \times vegetables) + (1 \times fruits) + (4 \times milk\ and\ milk\ products) + (0.5 \times oil/fats) + (0.5 \times sugar\ and\ honey)$

The FCS was then grouped into three threshold levels as set by WFP as follows; 0-21 poor, 21.5-35 Borderline > 35 Acceptable. A maximum FCS of 112 is achieved if a household has consumed all the designated eight food groups for 7 days.

Table 1: Food groups used to calculate HDDS and FCS

	HDDS		FCS	
	Food type	Score	Food type	Weight
1	Cereals	1	Staples	2
2	Roots and tubers	1		
3	Meats, poultry, offal	1	Meats	4
4	Fish	1		
5	Eggs	1		
6	Milk and milk products	1	Milk and milk products	4
7	Oils and fats	1	Oils and fats	0.5
8	Fruits	1	Fruits	1
9	Vegetables	1	Vegetables	1
10	Pulses and nuts	1	Pulses and nuts	3
11	Sugar/honey	1	Sugar/honey	0.5
12	Miscellaneous (sweets, condiments etc)	1	Miscellaneous (sweets, condiments etc)	Not counted

To evaluate the determinants of the HDDS and FCS, an ordered logit model was adopted since the scores were categorical and ordered (Uematsu and Mishra, 2011). For HDDS the ordering was as follows; 0 = Low dietary diversity (0-5), 1 = Medium dietary diversity (6-8), and 2 = High dietary diversity (8-12), and for FCS the variable was ordered as 0 = Poor (0-21), 1 = Borderline (21.5 – 35) and 2 = Acceptable (> 35). The ordinal logit model was built around a latent regression represented as;

$$Y^* = \beta' X_i + \varepsilon$$

Where the observed HDDS and FCS are represented by Y which is a function of Y^* considered to be an underlying continuous unmeasured latent variable that indexes the level of contribution of selected variables to the dependent variable. β is parameter vector to be estimated, X represents the explanatory variables, and ε is the random error term. Y^* exhibits itself in ordinal categories with various thresholds and is assumed to follow the following mapping:

For HDDS

$Y = 0$ if $Y^* \leq 0$, Low dietary diversity

$Y = 1$ if $0 < Y^* \leq \mu_1$, Medium dietary diversity

$Y = 2$ if $\mu_1 < Y^* \leq \mu_2$, High dietary diversity

For FCS

$Y = 0$ if $Y^* \leq 0$, Poor

$Y = 1$ if $0 < Y^* \leq \mu_1$, Borderline

$Y = 2$ if $\mu_1 < Y^* \leq \mu_2$, Acceptable

If the HDDs is 'Low' for example, then $Y^* \leq 0$ but the observed $Y = 0$. The μ's are unknown threshold parameters that are estimated with the β's in the model.

Results and discussions

Socio-economic and demographic characteristics

Majority of the households interviewed were male-headed (79% in the overall sample). There were significant differences between sex of the household heads ($\chi = 3.6$, p-value 0.058) with more female-headed households in Machakos (24%) than in Kirinyaga (18%) (Table 2). Over 70% of the household heads were above 46 years of age with an average age of 54 years in Kirinyaga, 58 years in Machakos as shown in Table 3. There was no significant difference between the level of education of household heads in Kirinyaga and Machakos County. The results in Table 2 shows that majority (45%) of the household heads in the overall sample had attained secondary school education with a mean number of years in school being 10.5 (Table 3). The main source of livelihood was farming with 75% engaged in this activity.

Table 2: Household socio-economic characteristics

Household characteristic	Statistic	County				Overall sample		χ^2	p-value
		Kirinyaga		Machakos					
		N	%	N	%	N	%		
Sex of the household head	Female	56	17.9	76	24.1	132	21.0	3.60**	0.058
	Male	257	82.1	240	75.9	497	79.0		
Age range	26-35	32	10.2	20	6.3	52	8.3	20.40***	0.0000
	36-45	60	19.2	32	10.1	92	14.6		
	46-55	94	30.0	86	27.2	180	28.6		
	56-65	57	18.2	85	26.9	142	22.6		
	>65	70	22.4	93	29.4	163	25.9		
Educational level of the household head	No formal education	11	3.5	8	2.5	19	3.0	5.50	0.139
	Primary	109	34.8	86	27.2	195	31.0		
	Secondary	129	41.2	154	48.7	283	45.0		
	Tertiary	64	20.4	68	21.5	132	21.0		
Major occupation of the household head	Self-employed (Business)	32	10.2	49	15.5	81	12.9	12.67***	0.002
	Farming (Own farm)	254	81.2	218	69.0	472	75.0		
	Employed (Private/public sector)	27	8.6	49	15.5	76	12.1		
Household current debt	Yes	93	29.7	82	25.9	175	27.8	1.11	0.292
Household did not have enough food in past 12 months	Yes	190	60.7	254	80.4	444	70.6	29.33***	0.000
If household kept Livestock	Yes	313	100	316	100	629	100		
If household sold livestock	Yes	172	55.0	178	56.3	350	55.6	0.121	0.728
If milk produced	Yes	270	86.3	221	69.9	491	78.1	24.47***	0.000
If member of an agricultural group/association	Yes	214	68.4	142	44.9	356	56.6	35.15***	0.000
If household accessed to extension services	Yes	3	1.0	7	2.2	10	1.6	1.59	0.208
If household accessed credit	Yes	124	39.6	101	32.0	225	35.8	4.01**	0.045

Less than a third (28%) of the households indicated that they had debts. Another 71% indicated that they experienced household food shortage with a higher percent being in Machakos (80%) than in Kirinyaga and this was significantly different. Further analysis shows that all the households interviewed kept cows and over 50% indicated that they sold livestock as at the time of survey. There were more households indicating milk production in Kirinyaga (86%) than in Machakos (70%). Slightly more than half (57%) of the households belonged to groups (68% in Kirinyaga and 45% in Machakos); about a third (36%) had access to credit (40% in Kirinyaga and 32% in Machakos) but only 1.6% had access to extension service.

Results in Table 3 further shows main demographic characteristics of the households. The average household size was 3 members. Household obtained income from both on-farm and off-farm sources. Household in Kirinyaga relied more on on-farm income compared to Machakos who relied more on off-farm income. The average household income from on-farm source was KES 19, 624 in Kirinyaga and KES 12,566 in Machakos; while the off- farm income was on average KES 9,386 for Kirinyaga and KES 10, 004 in Machakos. This is further confirmed by the results on how household ranked the different sources of income. In Kirinyaga, household ranked the importance of different income sources as 7.3 for crops, 7.0 for livestock and 4.4 for off-farm; and in Machakos the ranks were 6.9 from crops, 6.8 for livestock and 5.1 for off-farm. The importance of off-farm income in Machakos could be attributable to the agro-weather challenges which could hinder the farmers from concentrating more on on-farm activities and opting for off-farm activities.

Table 3: Household demographic characteristics

	County						F	p-value
	Kirinyaga (n=313)		Machakos (N=316)		Overall sample (n=629)			
	Mean	SD	Mean	SD	Mean	SD		
Age of household head	53.6	13.5	57.9	12.9	55.8	13.4	17.3	0.000***
Household size	2.6	1.3	3.1	1.7	2.9	1.5	21.58	0.000***
Monthly income of household head from off-farm source	9,386	15,851	10,004	16,951	9,696	16,403	0.22	0.637
Monthly income of household head from on-farm source	19,624	19,022	12,566	12,112	16,078	16,304	30.87	0.000***
Income for the household head	29,010	28,486	22,570	22,461	25,775	25,818	9.92	0.002***
Income of other household members	10,275	12,410	11,561	13,436	10,921	12,960	1.55	0.214
Gross household income	39,285	34,288	33,791	28,471	36,525	31,595	4.78	0.029**
Household expenditure	10,631	8,301	9,951	7,359	10,289	7,843	1.18	0.277
Importance of livestock keeping for the food security of your household	7.0	1.7	6.8	1.8	6.9	1.8	3.98	0.047**
Importance of crop production for the food security of your household	7.3	1.6	6.9	1.7	7.1	1.7	8.49	0.004***
Importance is off-farm income for the food security of your household	4.4	2.6	5.1	2.7	4.8	2.7	10.02	0.002***
Number of months of food shortage	2.7	2.7	4.0	2.7	3.4	2.8	41.84	0.000***
HDDS	5.9	1.4	5.7	1.6	5.8	1.5	3.11	0.078*
FCS	35.5	9.7	34.0	12.2	34.7	11.0	2.75	0.098*
Food expenditure per week	1,200.3	585.9	1,445.4	778.6	1,323.4	699.7	19.88	0.000***

*Significance levels *** 1%, ** 5% and * 10%*

As noted earlier, the percent of households experiencing food shortage was higher in Machakos than in Kirinyaga. Indeed the results in Table 3 shows that households in Machakos on average had 4 months of food shortage while in Kirinyaga the average was 2.7 months. There was a slight significant difference between the diversity and consumption scores in the two counties. The mean HDDS was 5.9 in Kirinyaga and 5.7 in Machakos (F = 3.11, p-value 0.078); and the mean FCS was 35.5 in Kirinyaga and 34 in Machakos (F = 2.75, p-value 0.098).

The average land size in the overall sample was 3.2 acres; 3.6 acres in Machakos and 2.8 acres in Kirinyaga (Table 4). The average land allocated to crops was 1 acre in Kirinyaga and 1.6 acres in Machakos. On average, household had 1.6 livestock units measured using tropical livestock units (TLUs[2]). The average milk produced per cow per day was 12 litres and there was no significant difference in the two counties. Looking at the different livestock kept by each household (which were cows, goats, sheep, poultry and pigs) the average value per household was KES 158,990 and this was significantly between the two counties (KES 177,309 in Kirinyaga and KES140, 188 in Machakos; F = 6.64, p-value 0.010). Of the households who had sold livestock at the time of survey, the average annual sales was KES 19, 748. The average distance to the market was 1.7.

[2] TLUs was calculated using the following formula: (Mature cow*0.5+Bulls*0.5 + Heifer*0.3+Young bull*0.3+Shoat *0.1+poultry *0.01, pigs* 0.2, calves*0.1)

Table 4: Land characteristics

Characteristic	County						F	P-Value
	Kirinyanga (n=313)		Machakos (n=316)		Overall sample (n=629)			
	Mean	SD	Mean	SD	Mean	SD		
Total land size (acres)	2.8	2.5	3.6	4.5	3.2	3.7	6.54	0.011***
Land under food crop (acres)	1.0	1.5	1.6	2.0	1.3	1.7	19.16	0.000***
Land under cash crop (acres)	0.4	0.9	0.3	0.8	0.4	0.8	3.99	0.046**
Land under fodder crop (acres)	0.3	0.8	0.4	1.1	0.4	1.0	1.67	0.197
Total livestock units (TLUs)	1.7	1.6	1.5	1.2	1.6	1.4	1.29	0.722
Quantity of milk produced (litres)	12.2	16.3	11.7	15.6	12.0	16.0	0.13	0.256
Total value of livestock (KES)	177,309	198,632	140,188	155,133	158,990	179,316	6.64	0.010***
Total sales from livestock (KES)	22,206	46,520	17,226	38,088	19,748	42,607	2.10	0.148
Distance to the nearest market (km)	2.1	1.7	1.8	1.6	2.0	1.7	6.34	0.012***

*Significance levels *** 1%, ** 5% and * 10%*

Dietary diversity and food consumption scores

Figure 1 shows the results on the percent of households falling at different thresholds of HDDS and FCS. For HDDS, majority of the respondent in the two counties were in the medium category (59% in Kirinyaga and 56% in Machakos). About a third (36%) of the overall sample were in the high dietary category. These results are corroborated by the FCS whose results equally shows that majority of the households were in the acceptable threshold (54% in Kirinyaga and 48% in Machakos). These two score shows that most of the households in both counties were food secure and had access to a wide variety of food types.

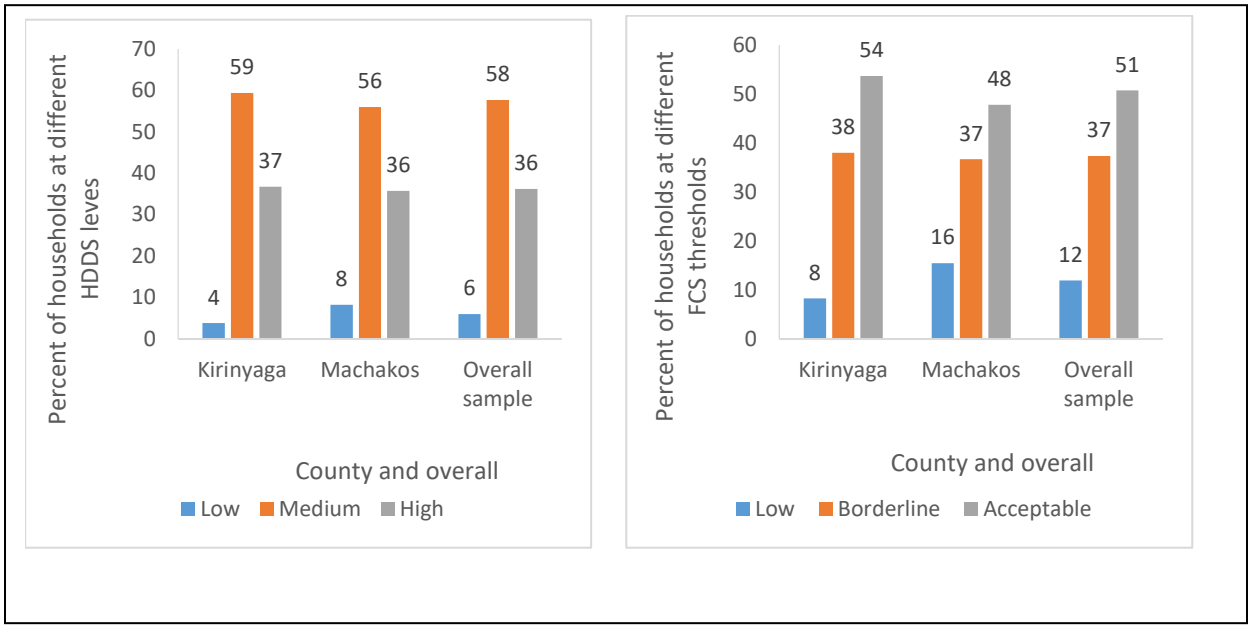

Figure 1: Household dietary diversity and food consumption scores

This study further evaluated the factors that influenced the diversity and consumption scores as shown in Table 1 and Table 6. The two models were significant (Prob> Chi = 0.000). For HDDS, the significant determinants were age of the household head, gross household income, and household perception on contribution of off-farm to food security (represented by the ranking), perception on food shortage, and number of months of food shortage, access to extension service and distance to the market. The variable representing age of the household head was positive and significant at 10%, implying that households where the heads were advanced in age had a diverse diet compared to those of younger age (coeff = 0.013, p-value 0.099). It can be argued that since most households who sourced their livelihood from farming were of advance age, they were likely to access a variety of food types through farming as opposed to young farmers who may be relying on off-farm income. Such young farmers would depend on purchase of foods which can sometimes be expensive and not affordable. On the other hand, Anyaeji and Arene (2010), argued that older household heads were likely to be more food secure than the younger ones owing to longer stay in employment, either public or private and hence earning more income.

The results further shows that household with higher gross income also had higher food diversity (Coeff = 0.000, p-value 0.038). This corroborates the findings of Annim and Frempong (2018)

who found a positive relationship between household dietary diversity and household's ability to access income and credit in Ghana. This argument is also well supported in economics by the demand elasticity where consumption (especially of luxury goods) increases with increase in income. Besides sourcing food from their farms, households with a higher gross income are considered economically empowered to purchase other nutritious foodstuff to supplement what is produced at home.

Households that highly ranked off-farm income as important to food security also had higher food diversity compared to those who gave it a lower rank (coeff = 0.110, p-value 0.008). Aidoo *et al.* (2013) urges that off-farm income have a positive effect on food security because this may lead to improvement in capacity to produce more food as well as to purchase from other sources.

The variable representing households' perception on food shortage was also positive and significant, implying that households who perceived food shortage in their homes, had higher diversity score (coeff = 1.015, p-value = 0.005). Although this was found interesting and at the same time contradictory, it may mean that such households made extra efforts to buy alternative foodstuff in order to cope with the food shortage, and hence ended up eating diverse food types. However, the variable representing the number of months that a household experienced food shortage was negative and significant (coeff = -0.150, p-value = 0.017) implying that the more the months a household experienced food shortage, the lesser the diversity. Farmers who had access to extension service were also found to have a diverse diet compare to those who did not access (Coeff = 1.502, p-value =0.084). Access to extension can be attributed to increased productivity since farmers are able to learn more about improved innovations. Kassie et al. (2012) observed that food security in female-headed households increased with the increase in quality of extension service. Furthermore, through extension training farmers are also taught about diversification of their foods at the farm as well meal recipes by practicing nutritionally sensitive agriculture.

Distance to the market was inversely related to HDDS level (coeff = -0.264, p-value 0.000) implying that household that were far removed from the market had less diversity compared to those who were closer to the market. When farmers are not able to produce enough, they rely on the market. Therefore, if the markets are very far, with poor accessibility, these household will have limited food types. Stefan *et al.* (2017) found that access to markets for buying food and selling farm produce are more important for dietary diversity than diverse farm production.

Table 5: Determinant of household dietary diversity score

Variables	Description	Coef.	Std. Err.	z	p -value
Sex of household head	0=Female, 1 = Male	0.010	0.259	0.040	0.970
Age of household head	Continuous (years)	0.013	0.008	1.650	**0.099***
Education of the household head	0= No formal, 1 =Primary, 2 =Secondary, 3 =Tertiary	-0.137	0.139	-0.980	0.325
Occupation of the HH	1 = Self-employed (Business), 2 = Farming (Own farm), 3 = Employed (Private/public sector)	0.059	0.210	0.280	0.778
Household size	Continuous	0.036	0.074	0.480	0.631
Gross household income	Continuous	0.000	0.000	2.080	**0.038****
Household expenditure	Continuous	0.000	0.000	-1.290	0.197
Rank for Livestock to food security	Continuous 0-10	0.009	0.063	0.150	0.884
Rank for crops to food security	Continuous 0-10	0.043	0.062	0.690	0.488
Rank for off-farm to food security	Continuous 0-10	0.110	0.041	2.660	**0.008***
Household debt	0 = No, 1 = Yes	-0.366	0.373	-0.980	0.326
Experience of food shortage	0 = No, 1 = Yes	1.015	0.359	2.830	**0.005*****
Number of food shortage months	Continuous	-0.150	0.063	-2.380	**0.017*****
Total land size	Continuous	-0.034	0.033	-1.060	0.290
Land under food crop	Continuous	-0.006	0.064	-0.090	0.928
Land under cash crop	Continuous	0.079	0.121	0.650	0.514
If livestock was sold	0 = No, 1 = Yes	-0.215	0.220	-0.980	0.327
Quantity of milk produced per day	Continuous	0.007	0.009	0.820	0.412
Group membership	0 = No, 1 = Yes	0.264	0.210	1.260	0.208
Access to extension	0 = No, 1 = Yes	1.502	0.868	1.730	**0.084***
Access to credit	0 = No, 1 = Yes	0.321	0.352	0.910	0.363
Tropical Livestock unit (TLUs)	Continuous	0.105	0.100	1.050	0.293
Livestock sales (KES)	Continuous	0.000	0.000	0.740	0.462
Distance to the market	Continuous	-0.264	0.066	-4.030	**0.000*****
Study county	1 = Kirinyaga, 2 = Machakos	-0.104	0.224	-0.460	0.643
/cut1		-1.701	0.995		
/cut2		2.112	0.986		

N = 474, LR chi2 (25) = 69.160, Prob > chi2 = 0.000, Pseudo R2 = 0.087, Log likelihood = -361.997

*Significance levels *** 1%, ** 5% and * 10%*

For the determinants of FCS, the following variables were significant; Gross household income (coeff = 0.000; p-value = 0.001), household expenditure (coeff = 0.000; -value = 0.013), rank for crop on food security (coeff = 0.161; p-value = 0.008), and distance to the market (coeff = -0.256; p-value = 0.000) (Table 6). As noted earlier, high gross income give the households ability to consume not only a diverse diet but also to do so frequently, hence the positive effect on FCS. Furthermore, the more the household is able to buy more food also increases the expenditure level. This thus explains the positive relationship between expenditure and FCS (Kassie et al., 2012; Aidoo *et al.* 2013).

Farmers who perceived crop enterprise as very important were more food secure (Acceptable FCS) compared to those who ranked it low. The positive relationship between this variables representing farmers' ranking of the contribution of crop enterprise to food security and FCS can be explained to mean that farmers who valued crop production more, were likely to put more effort in farming, increase productivity and hence have more for consumption as well as for sale. In view, they will have enough to eat frequently and also extra income to purchase other food items. Increased crop productivity also leads to reduced food prices at the market level and therefore the food becomes more affordable.

Finally, the variable for distance to the market was inversely related to FCS implying that those households that were far from the market were less food secure. Market accessibility is considered as one of the most important factors affecting rural food security and this is attributed to the complex food supply chain. Without a proper transport and infrastructure system, the gains of increased productivity and hence food security cannot be transferred.

Table 6: Determinant of household food consumption score

Variable	Description	Coef.	Std. Err.	z	P>|z|
Sex of household head	0=Female, 1 = Male	-0.333	0.263	-1.270	0.206
Age of household head	Continuous (years)	0.002	0.008	0.200	0.839
Education of the household head	0= No formal, 1 =Primary, 2 =Secondary, 3 =Tertiary	-0.010	0.141	-0.070	0.942
Occupation of the household head	1 = Self-employed (Business), 2 = Farming (Own farm), 3 = Employed (Private/public sector)	-0.130	0.218	-0.600	0.551
Household size	Continuous	-0.086	0.077	-1.130	0.260
Gross household income	Continuous	0.000	0.000	3.390	**0.001*****
Household expenditure	Continuous	0.000	0.000	2.490	**0.013*****
Rank for Livestock to food security	Continuous 0-10	-0.056	0.064	-0.870	0.383
Rank for crops to food security	Continuous 0-10	0.161	0.061	2.670	**0.008*****
Rank for off-farm to food security	Continuous 0-10	0.057	0.041	1.390	0.165
Household debt	0 = No, 1 = Yes	0.170	0.384	0.440	0.659
Experience of food shortage	0 = No, 1 = Yes	0.124	0.232	0.530	0.593
Total land size	Continuous	0.043	0.039	1.090	0.274
Land under food crop	Continuous	0.050	0.077	0.650	0.515
Land under cash crop	Continuous	0.201	0.146	1.380	0.168
Quantity of milk produced per day	Continuous	-0.002	0.010	-0.190	0.851
Group membership	0 = No, 1 = Yes	0.225	0.213	1.060	0.290
Access to extension	0 = No, 1 = Yes	0.452	0.883	0.510	0.609
Access to credit	0 = No, 1 = Yes	-0.144	0.365	-0.400	0.692
Tropical Livestock unit (TLUs)	Continuous	0.042	0.112	0.380	0.705
Livestock sales (KES)	Continuous	0.000	0.000	-0.480	0.631
Distance to the market	Continuous	-0.265	0.063	-4.240	**0.000*****
Study county	1 = Kirinyaga, 2 = Machakos	-0.108	0.225	-0.480	0.632
/cut1		-1.702	0.977		
/cut2		1.048	0.972		

N = 475, LR chi2 (25) = 95.9, Prob > chi2 = 0.000, Pseudo R2 = 0.115, Log likelihood, -370.59
*Significance levels *** 1%, ** 5% and * 10%*

3.0. Conclusions and recommendations

This study was carried out to evaluate the food security levels of the beneficiaries of the InnovAfrica project. The study used the qualitative measure represented by the HDDS and FCS to classify the food security status and also identified the determinants using an econometric model. The results presents useful information that contributes to the body of literature on food security. The households were mainly male-headed of advanced age with relatively high literacy. For most of the variable analysed, there was a significant difference between the sample counties and this represents the real situation since Mackakos and Kirinyaga have distinct differences especially in term of agro-weather patterns and cultural diversities. However, when it comes to the food security elements as presented by HDDS and FCS, the differences were minimal. They means that despite the challenges faced by one county in terms of weather challenges that could be detrimental to food situation, it is possible that the residents always had their own mechanism of coping. For example, even though Machakos County was a bit challenged in terms of weather, the results shows that they opted to rely more on off-farm income to circumvent the problem. On the other hand, farmers in Kirinyaga has smaller pieces of land, yet they were able to keep more livestock, most likely through intensification. In both cases, farmers were able to raise more gross household income, which was in turn used to improve the household dietary diversity as well as the consumption score. Given the different factors that influence food security, efforts should be made to assist farmers to diversify their income sources in their quest to attain the minimum food requirement.

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