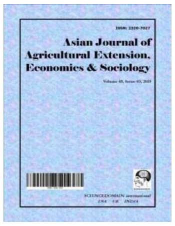

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Effects of Land Fragmentation on Food Security in Three Agro-ecological Zones of Embu County in Kenya

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Authors' contributions

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

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ABSTRACT

Land fragmentation is a common agricultural phenomenon in many countries where a single large farm is subdivided into a large number of separate small land plots. This paper is based on a study that was carried out to evaluate the impact of land fragmentation on food security in three agro-ecological zones (AEZs) of Embu County in Kenya from January to November 2016. The study used data collected from 384 farm-households that were randomly selected from three AEZs in the Embu County, using the 4-stage cluster sampling method. The AEZs were the Sunflower-Cotton Zone, the Coffee Zone and the Tea Zone, based on the official AEZs classification system in Kenya. Household caloric acquisition method was used to compute a household food security index (HFSI) that was used to measure the household food security status. The effect of farm size on food security was evaluated using the Binary Logit Regression method. The results showed that the average number of people in a household was 3.73 in the Tea Zone, 3.59 in the Coffee Zone and 3.93 in the Sunflower Zone, and that farm size had a positive and significant effect on food security

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in the Sunflower (*P=.029*) and Tea zones (*P=.007*), but not in the Coffee Zone (*P=.365*). Further, it was found that the minimum farm-size that could ensure the attainment of the minimum (cut-off) point for household food security (HFSI = 1) was above 2 ha in the Sunflower Zone and 0.5 ha in the Tea Zone. Based on the study findings, it is recommended that further fragmentation of farms below 0.5 ha in the Coffee and Tea zones and 2 ha in the Sunflower Zone should be discouraged to ensure sustainable food security in the study area. For the farms that are already below the minimum cut-off size for food security, measures to increase these farms' productivities so that they can support more people per ha should be devised and implemented.

Keywords: Land fragmentation; farm size; agro-ecological zones; food security.

1. INTRODUCTION

1.1 Food Security Status

Food security may be defined as "access by all people at all times to sufficient food for an active and healthy life" [1]. However, the World Food Summit and the Food and Agriculture Organization of the United Nations modified this definition to state that food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [2]. Conceptually, food security has four dimensions, namely food availability, access, stability and utilization [3]. Food availability captures the quantity, the quality and the diversity of food available to the people. The indicators of food availability include adequacy of dietary energy and protein obtained from the available food. Food access captures the peoples' physical and economic access to food. The indicators of food access include domestic food price index and physical infrastructure (roads, railways, and storage facilities) that make food available to the people. Food stability captures peoples' exposure to risk of food insecurity due to incidences of shocks, such as domestic food price volatility, fluctuations in domestic food supplies, political instability and peoples' loss of income. Food utilization dimension focuses on peoples' ability to utilize food as indicated by stunting, under-weight, anaemia and vitamin A deficiency among children under five, and prevalence of iodine deficiency and anaemia among pregnant women. Thus food insecurity will exist to a small or large extent depending on the extent to which one or more of the four dimensions food security is/are violated. More practically, food insecurity is said to exist when people's calorie intake is below the minimum dietary energy requirement and will manifest itself as hunger or undernourishment [2].

The number of undernourished people in the world by 1996 was estimated at about 800 million, with about 780 million (98%) of these people living in the developing countries [3]. Sub-Saharan Africa (SSA) is home to about 220 million people who fail to meet their daily dietary energy requirements, which is about 23% of the total population in SSA [3]. Food insecurity in Kenya by 2010 was estimated at over 10 million (about 25%) of the total population [4]. Among the undernourished people in Kenya, an estimated 1.5 million require emergency food assistance annually [5,6].

The concern about world food insecurity has dominated the global agenda for many decades, as expressed in many international conferences since the 1980s. Most of the world leaders have accepted that food insecurity is a serious impediment to sustainable socio-economic development and a threat to world peace and is morally unacceptable [7]. For the first time in the global agenda, the World Food Summit (WFS) that was held in 1996 set a global target to address food insecurity in the world. The WFS target was to reduce the absolute number of undernourished people to half the 1996 level (800 million) by 2015 [7]. The WFS commitments were reinforced by the United Nations (UN) Millennium Summit that was held in 2000 whose deliberations led to the setting of the targets for the eight UN Millennium Development Goals (MDGs) of which the target on food security/insecurity was a component [2].

1.2 Statement of the Problem

Despite the concerted global and national efforts to fight food insecurity, undernourishment is still rampant in the world in general and Kenya in particular. Food insecurity in Kenya is estimated at over 10 million people (about 25% of the total population) [4]. Among the undernourished people in Kenya, an estimated 1.5 million require emergency food assistance annually [5]. Land fragmentation has been cited as one of the major causes of food insecurity in Kenya [8,9]. This citation may be due to the fact that land fragmentation is rampant in most high agricultural potential areas in Kenya, mainly due to increasing population pressure [2], but there is limited evidence from empirical studies. However, land size is expected to impact on the farm's contribution to household food security through its effect on the quantity of food produced and the amount of farm income generated.

Given the concern by the Government of Kenya about the perceived negative impact of land fragmentation on food security in the country, a number of institutional and policy measures are being undertaken to address this problem. Such measures include the provision of extension services and formulation of a number of legal and policy documents, including the Constitution, to guide the process of curbing the menace of land fragmentation. For example, the Article 60 of the Kenyan Constitution [10] points out that land in Kenya shall be managed in a manner that is equitable, efficient, productive and sustainable. The Article 68 (c) of the Constitution mandates Parliament to regulate land size by prescribing the minimum and maximum land holding acreages in respect of private land. One of the Kenya Vision 2030 flagship projects is the development of a National Land Use Master plan, with Agricultural Land Use Plan as part of it [8], which is expected to boost the efforts targeting efficient utilization of all forms of land in Kenya. However, the government efforts to address land fragmentation have been hampered by lack of adequate and reliable research-based information to guide policy formulation on land management and its impact on food security.

The previous studies which have been conducted to evaluate the impact of farm size on household food security have been found to be inconclusive. These studies have two main shortcomings: their failure to evaluate the influence of agro-ecological zones on the impact of farm size on household food security, and their failure to determine the minimum farm size that can ensure household cut-off food security status. For this reason, the current study was conducted to examine the impact of land fragmentation on household food security across three different AEZs in Kenya, using the data collected from Embu County in Eastern Kenya as a case study. The three agro-ecological zones were the Sunflower-Zone (Upper Midland zone 4 and Lower Midland Zone 3), the Coffee Zone (Upper Midland Zone 1-3) and the Tea Zone (Lower Highland Zone 1-2), following the Jaetzold et al. [11] categorization of the AEZs in Kenya. Using a sample stratified on the basis of the three AEZs, the effect of farm-size on food security was evaluated in each AEZ. The minimum farm-size required to ensure the minimum cut-off food security status was determined for each of the three AEZs.

1.3 Objectives of the Study

The broad objective of this study was to evaluate the impact of land fragmentation and AEZS on food security in Kenya through a case study of the Embu County. Specifically, the study aimed at evaluating the impact of farm-size on household food security across different AEZs in the Embu County which has relatively small landholdings that are symptomatic of the extent of land fragmentation in the high agricultural potential areas of Kenya. The study basically tested the hypothesis that farm-size has no statistically significant impact on household food security in and across different agro-ecological zones in the Embu County and, by extension, in Kenya.

2. RESEARCH METHODOLOGY

2.1 Sample Size

Household food security status in the study area was measured using data collected from a sample comprising 384 households drawn from three AEZs. The sample size was determined using the following formula [12]:

$$N = \frac{z^2 p(1-p)}{d^2} \tag{1}$$

Where:

- N = the desired sample size
- Z = the standard normal deviate at the required confidence level
- P = the proportion of the target population estimated to have the characteristic being measured
- 1-p = the proportion of the population without the characteristic being measured
- d = the level of statistical significance set

The standard normal deviate was set at 1.96 which corresponds to 95% confidence level. Since there was no available estimate of the proportion of the target population with the characteristic of interest, 50% is assumed to have that characteristic. The level of statistical significance corresponding to 95% confidence level is 0.05. The sample size was therefore calculated as follows:

$$N = \frac{(1.96)^2 (0.5)(1-0.5)}{(0.05)} = 384 \quad (2)$$

2.2 Sampling Procedure

The study used a combination of a four-stage cluster sampling and probability proportionate to size sampling procedures. One administrative location was randomly selected from each of the 4 administrative divisions randomly selected from each of the three AEZs making a total of 12 administrative locations selected from the study area. One administrative sub-location was randomly selected from each of the 12 locations, followed by random selection of one administrative village from each sub-location and therefore making a total of 12 villages selected from the study area. The proportion of the village population relative to the total for all the villages was used to determine the number of farms to be interviewed in each village. The number of farms to be interviewed was determined using the following formula:

$$M = \frac{n}{N} * 384 \quad (3)$$

Where:

M = number of households to be interviewed
n = No. of households in the village
N = total No. of households in the 12 villages

In total 134 households were selected for interview in the sunflower zone, 133 in coffee zone and 117 in the tea zone making a total of 384 households.

2.3 Data Collection

Data on the types and quantities of food taken and produced by each of the household in the sample were collected using a structured questionnaire. Such data were collected during the long-rain (LR) and short rain (SR) seasons in order to capture seasonal variations in food intake. The long rain (LR) season in Kenya starts in March and ends in August when the farmers harvest the crops planted at the onset of the long rains, while the short rain (SR) season starts in September and ends in February of the following year.

2.4 Empirical Model

The available literature shows that four major approaches in the measurement of household food security have been employed in the past, namely the assessments of individual food intake, household caloric acquisition, dietary diversity, and indices of household coping strategies. The individual food intake method measures the amount of calories or nutrients consumed by an individual in a given time period, usually 24 hours [13]. The household caloric acquisition method measures the number of calories, or nutrients, available for consumption by household members over a defined period of time [14]. Dietary diversity is the number of food items or food groups eaten by the household over a given period of time [15]. The indices of coping strategies method uses indices that are based on the actions which households take when they do not have enough food or money to buy food [16].

Previous studies show that farm size positively affects food security through its influence on food production, farm income and farm efficiency. Such previous studies include [17,18,19, 20,21,22,23]. These studies have found that the households owning large farms have better chances of producing more food and cash crops and have more space for crop diversification [24]. The main research gap identified in the previous studies is their failure to examine and compare the impact of farm size on food security across different agro-ecological zones (AEZS). The previous studies have also not determined the minimum farm size that will ensure the attainment of the minimum cut-off for food security in each AEZ on the basis of the household food security index (HFSI).

For analytical purposes, an Agro-Ecological Zoning refers to the division of an area of land into smaller units which have similar characteristics that are related to land suitability, potential production and environmental impact. An Agro-ecological Zone (AEZ) is thus a land resource mapping unit, defined in terms of climate, land form and soils, and/or land cover, and having a specific range of potentials and constraints for land use [25]. Jaetzold, et al. [26] classify the land in Kenya into 7 main AEZs on the basis of the original natural vegetation cover. Zones 0-3 were originally forest zones or highlands, zones 4-6 were originally savannah grasslands with intermittent short trees and shrubs, and zone 7 was originally a semi desert. These main AEZs in Kenya are further classified into zone groups based on maximum temperature limits and water requirements within which the main crops grown in Kenya can flourish. The lowland (LL) zones are based on cashew and coconut, the lower midlands (LM) zones are based on cotton and sugarcane, the upper midland (UM) zones are based on coffee, the low highlands (LH) zones are based on tea, and the upper highlands (UH) zones are based on pyrethrum. This zoning was the basis for the three AEZs covered in the Study Area in the Embu County, namely the Sunflower-Zone (UM 4 and LM 3), the Coffee Zone (UM 1-3) and the Tea Zone (LH 1-2),

The Sunflower Zone comprises upper midland 4 (UM 4) and lower midland 3 (LM 3). The Zone receives the lowest amount of annual rainfall among the three AEZs (900 mm -1200 mm), with maize, beans and mangoes being the main crops grown (26). The Coffee Zone comprises upper midland zones 1 to 3 (UM 1-3). The annual rainfall in the Coffee Zone ranges from 1200 mm to 1400 mm, with the main crops being coffee, maize, beans, bananas and macadamia. Among the three agro-ecological zones, the Coffee Zone is the closest to the three major towns in Embu County, namely Embu and Runyenjes. In addition, the main road from Nairobi to Meru town passes through the Coffee Zone. The Tea Zone comprises low highland zone 1(LH 1), low highland zone 2 (LH 2) and some parts of upper midland 1 (UM 1). The Zone receives average annual rainfall ranging from 1400 mm to 1800 mm, which is the highest among the three AEZ. Tea, maize, beans and macadamia are the main crops grown in the Tea Zone (26). The Tea Zone borders the Mount Kenya Forest and exploitation of forest resources could have a positive influence on food security in the Tea Zone.

The study used the household caloric acquisition method, based on Hoddinott [13], to determine the level of household food security. The caloric acquisition method measures the level of household food security as a ratio of the total energy available in the food items taken by the household per day to the recommended daily energy requirement for the household. This is expressed as [20]:

$$HFSI = \frac{HDCI}{HDCR} \tag{4}$$

Where:

HFSI= household food security index
HDCI= Household daily calorie intake
HDCI= Household daily calorie requirement

The quantities of food items taken by the household were all converted into a common unit, kilograms. The food quantities were then converted into calories using the food composition table provided by Technical Centre for Agricultural and Rural Cooperation/ East, Central and Southern Africa Food and Nutrition Centre [26].

To determine the household daily energy requirement, the household members were first categorized on the basis gender and the age brackets as used by FAO /WHO/UNU [27] in providing the recommended human energy requirements. The human energy requirement is defined as the amount of dietary energy required by a human being to maintain body size, body composition and a light level of physical activity [27]. Using the FAO and WHO recommended daily energy requirement, the total household daily energy requirement was determined for each of the household in the sample.

The household food security index (HFSI) was determined for each household in the sample. Households that had HFSI<1 were classified as food insecure since they have not met their daily calorie requirement. Households that had HFSI ≥ 1 were classified as food secure since they had met or exceeded their daily calorie requirement. The sample was then stratified on basis of the three AEZs (Sunflower, Coffee and Tea zones).

To enable comparative analysis of the effect of land size on food security in the three AEZs, land size for each household was normalized using Z-score transformation as given in equation 5 [28]:

$$Z_{K,i} = \frac{V_{K,i} - \overline{V}_K}{\delta_K} \tag{5}$$

Where:

$Z_{K,i}$= Z-score for land size owned by the i^{th} household in a given AEZ K

V_K= land size owned by the i^{th} household

$\overline{V}_k$ = average farm size for a given AEZ

δ_k = standard deviation for a given AEZ

The effect of land size on HFSI in the 3 AEZs was determined using Binary Logit regression with food insecure households taking the value of "0" and the food secure households taking the value of "1". The computed Z-score were used as a continuous independent variable representing land size.

The households in each AEZ were further categorized into five farm-size categories. The farm size categories are given in Table 1. The farm sizes are given in hectares (ha). In the Metric System of measurement, 1 ha is equivalent to 10,000 square meters. The average HFSI was calculated for each farm size category. The minimum farm size for attainment of threshold food security was determined as the farm size category in which HFSI=1.

Table 1. The farm size categories used in the analysis

Category	Hectares
1	0 - <0.25 Ha
2	0.25 - <0.5 Ha
3	0.5 - <1.0 Ha
4	1.0 - < 2.0 Ha
5	≥2.0 Ha

Source: Survey data, 2016

3. DATA ANALYSIS AND DISCUSSION OF THE FINDINGS

3.1 Household Food Security Status across Different AEZs

The results on food security status in and across different AEZs in the study area are presented and discussed in this section. The findings are presented in the form of means, frequencies, percentages and Binary Logit Regression analysis results.

Table 2 shows that the level of food security in the study area varies with the AEZs. Based on the mean HFSI and the percentage of the food secure households, the Tea Zone had the highest level of food security (0.98; 43.6%) and the Sunflower Zone had the lowest (0.75; 17.2%). A possible explanation could be that the Tea Zone which receives an annual rainfall of 1400-1800 mm has a higher agricultural potential than the Sunflower Zone which receives 900-1200 mm of annual rainfall [11]. In addition, tea is the dominant crop in the Tea Zone and has a higher market value than maize and beans which are the dominant crops in the Sunflower Zone, suggesting that income from tea could be used to enhance the household food security status.

3.2 The Effect of Farm-size on Food Security

The results of the Binary Logit regression analysis for land size are as given in Table 3. The results show that the effect of land size on food security was significant in the Sunflower Zone (*p=.029*) and the Tea Zone (*p=0.007*), but was not significant in the Coffee Zone (*p=.365*). The β-coefficient was positive in the two zones (Sunflower and Tea), implying that land size had a positive effect on food security. The effect of land size on food security was higher in the Tea Zone (*β=.706*) than in the Sunflower Zone (*β=.354)*. The β-coefficients of 0.354 and 0.706 indicate that the probability of a household being food secure increases by 35.4% and 70.6% per unit increase in land size. The odd ratio associated with land size was found to vary with the AEZs: 1.424 in Sunflower Zone and 2.025 in the Tea Zone. This implies that the odds to be food secure is 1.4 times that to be food insecure for a household owning a large farm in the Sunflower Zone and about 2 times for a household in the Tea Zone.

Table 2. Food security status in different AEZs

AEZs	Total number of households	Mean HFSI	Number of food secure households	Percentage of food secure households
Sunflower	134	0.75	23	17.2
Coffee	133	0.98	55	41.4
Tea	117	0.98	51	43.6
Total	384	0.90	129	33.6

Source: Survey data, 2016

Table 3. Results of binary logit regression analysis for land size

AEZs	B-coefficient	SE	Wald	Odd-ratio	p-value
Sunflower	0.354	0.162	4.77	1.424	0.029*
Coffee	0.159	0.176	0.82	1.172	0.365
Tea	0.706	0.263	7.22	2.025	0.007**

*Significance level: * p-value<0.05, ** p-value<0.01*
Source: Survey data, 2016

3.3 Farm Size for Attainment of Threshold Food Security in the Sunflower Zone

Based on the study results, the mean household food security index (HFSI) for each farm size category in the Sunflower Zone is given in Table 4. The mean average HFSI in the Sunflower Zone was found to increase as farm size increases, confirming a positive relationship between farm size and food security in this zone.

Table 4. The mean HFSI for the farm-size categories in the sunflower zone

Farm- size	Number of households	Mean HFSI
0 - <0.5 ha	32	0.49
0.5 - <1.0 ha	41	0.71
1.0 - <2.0 ha	37	0.83
2.0 ha & above	24	0.80

Source: Survey data, 2016

On the basis of the household food security index (HFSI), the minimum farm-size that can guarantee the attainment of an acceptable level of food security status should be the farm-size category in which the average HFSI is equal to 1. In the Sunflower Zone, none of the farm size categories was found to meet this threshold HFSI. The farm size category of 1.0 - <2.0 ha was found to have the highest mean HFSI (0.83); however, the HFSI for the farm size category of "2.0 ha & above" was slightly lower at 0.80, but 0.83 and 0.80 are close enough. Therefore, the farm size that could ensure the minimum cut-off food security in the Sunflower Zone was taken to be above 2.0 ha. However, the minimum farm-size for a given agro-ecological zone, based on food security, is not static and may be expected to change with changes in farm productivity and other factors that affect food security in a particular agro-ecological zone.

3.4 Farm Size for Attainment of Threshold Food Security in the Coffee Zone

On the basis of the study results, the mean HFSI for each farm size category in the Coffee Zone are given in Table 5. The mean average HFSI was found to increase as farm size increases, indicating a positive relationship between farm size and food security in the Coffee Zone.

Table 5. The mean HFSI for the farm-size categories in the coffee zone

Farm-size	Number of households	Mean HFSI
0- <0.25 ha	43	0.91
0.25- <0.5 ha	43	1.03
0.5- <1.0 ha	25	1.01
1.0 ha & above	22	1.11

Source: Survey data, 2016

The effect of land size on HFSI was found not to be significant in the Coffee Zone as given Section 3.2. A possible explanation for this unexpected finding could be that the people living in the Coffee Zone enjoy more opportunities for off-farm income, such as business and employment, which reduce the importance of the perennial coffee crop as the anchor food security crop. This explanation appears plausible because, among the three agro-ecological zones covered in the study, the Coffee Zone is the one closest to the two major towns in the Embu County, namely Embu and Runyenjes. In addition, the main road from the City of Nairobi to the Meru Town via Embu Town passes through the Coffee Zone. The importance of the farm-size in determining the household food security in the Coffee Zone is thus reduced by these factors.

3.5 Food Security Status across Different Farm Size Categories in the Tea Zone

Based on the study results, the mean HFSI for each farm size category in the sample drawn from the Tea Zone are given in Table 6. The mean average HFSI was found to increase as farm size in the Tea Zone increases, indicating a positive relationship between farm size and food security in this zone.

On the basis of the HFSI, the minimum farm-size that could ensure minimum cut-off food security in the Tea Zone was found to be in the category of 0.5 - 1.0 ha as shown in Table 6.

Table 6. The mean HFSI for the farm-size categories in the tea zone

Farm-size	Number of households	Mean HFSI
0- <0.25 ha	27	0.92
0.25- <0.5 ha	42	0.94
0.5- <1.0 ha	26	1.07
1.0 ha & above	22	1.21

Source: Survey data, 2016

4. CONCLUSION

Based on the study findings, it was concluded that farm size has a positive impact on household food security in the study area. However, the impact of farm size on food security varies with the agro-ecological zone, indicating that the influence of the agro-ecological zone is significant. The minimum cut-off farm size for food security status also varies with the agro-ecological zone.

The findings of this study are consistent with those from the previous studies with regard to the impact of farm size on food security. However, this study contributes to the existing body of knowledge by showing that the impact of farm size on food security varies within and across AEZs. Within any AEZ, the households owning large farm sizes have better chances of producing more food and cash crops, and have more space for crop diversification [24,29,30,31]. Large farms also generate large volumes of crop residues for livestock production which enhances food security. Therefore, the size of a land holding may be expected to have a positive effect on a host of such factors as household wealth, access to credit, capacity to bear risk and household income which individually or jointly influence a household's food security status [17]. Agro-ecological zones interact with farm size in the determination of the minimum farm size that can guarantee the attainment of an acceptable food security status, based on the HFSI estimate for a household in a given AEZ.

5. RECOMMENDATIONS

The results of this study have revealed that farms below 2.0 ha and 0.5 ha in size in the Sunflower and Tea zones respectively were unable to attain food security. Policy should therefore be implemented to discourage subdivision of farms that are less than 2 ha in the Sunflower Zone and less than 0.5 ha in the Tea Zone. However, such policy should be reviewed as land productivity increases and thus makes it possible to support more people per ha in a particular AEZ. For the farms that are already below the minimum cut-off size for food security attainment, measures to increase these farms' productivities should be devised and implemented so that these farms can support more people per ha. Such measures may include the development and adoption of technologies that increase farm production and increased diversification of household sources of income.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Bank. Poverty and hunger: Issues and options for food security in developing countries. World Bank Policy Study, Washington D.C.; 1986.
2. FAO (Food and Agricultural Organization). The state of food and agriculture. Rome, FAO; 2009.
3. FAO. (Food and Agricultural Organization). Regional overview of food insecurity: African food insecurity prospects brighter than ever. Accra, FAO; 2015.
4. NFNSP (National Food and Nutrition Security Policy). Agricultural Sector Coordination Unit, Nairobi; 2011.
5. FEWS-NET (Famine Early Warning System Network). Kenya food security outlook. USAID, Nairobi; 2015.
6. UNICEF. Humanitarian situation report. Kenya Country Office, Nairobi; 2015.
7. Shaw DJ. World food security: A history since 1945. Palgrave MacMillan, New York; 2007.
8. GOK (Government of Kenya). Kenya Vision 2030. Government Printers, Nairobi; 2008.
9. GOK (Government of Kenya). National land use policy. Physical Planning Department, Ministry of Lands and Physical Planning, Nairobi; 2016.
10. GOK (Government of Kenya). The constitution of Kenya. Government Printers, Nairobi; 2010.
11. Jaetzold R, Schmidt H, Hornetz B, Shisanya C. Farm management handbook of Kenya Vol. II: Natural conditions and farm management information. 2nd Edition; 2006.

12. Cochran WG. Sampling techniques (3rd edition). New York: John Wiley & Sons; 1977.
13. Hoddinot J. Choosing outcome indicators of household food security. International Food Policy Research Institute, Washington D.C.; 1999.
14. Smith LC, Subandaro A. Measuring food security using household expenditure surveys. International Food Policy Research Institute, Washington D.C.; 2007.
15. World Food Programme (WFP). Validation of food frequency and dietary diversity as proxy indicators of household food security report submitted to: World food programme by: International Food Policy Research Institute (IFPRI); 2008.
16. Maxwell D, Ahiadeke C, Levin C, Armar-Klemesu M, Zakariah S, Lamptey GM. Alternative food-security indicators: Revisiting the frequency and severity of "coping strategies". Food Policy. 1999;24: 411-29.
17. Mitiku A, Fufa B, Tadese B. Empirical analysis of the determinants of rural household's food security in Southern Ethiopia: The case of Shashemene District. Basic Research Journal of Agricultural Science. 2012;1(6):132-138.
18. Faridi R, Wadood SN. An econometric assessment of household food security in Bangladesh. Research Center Journal International. 2010;1(1):56-59.
19. Kuwornu JKM, Suleyman DM, Amegashie DPK. Analysis of food security status of farming households in the forest belt of the Central Region of Ghana. Russian Journal of Agricultural and Socio-Economic Sciences. 2013;1(13):26-42.
20. Omotesho OA, Adewumi MO, Fadimula KS. Food security and poverty of the rural households in Kwara State, Nigeria. Libyan Agriculture. Libyan Agriculture Research Center Journal International. 2010;1(1):56-59.
21. Osei MJ, Aidoo R, Tuffour T. Determinants of household food security in the Sekyere-Afram plains District of Ghana. Global Advanced Research Journal of Agricultural Science. 2013;2(1):34-40.
22. Haile HK, Alemu ZG, Kudhlande G. Causes of household food insecurity in Koredegaga Peasant Association, Oromiya Zone, Ethiopia. Working Paper. Department of Agricultural Economics Faculty of Natural and Agricultural Sciences at the University of the Free State; 2005.
23. Kaloi E, Tayebwa B, Bashaasha B. Food security status of households in Mwingi District, Kenya. African Crop Science Conference Proceedings. 2002;7:867-873.
24. Bogale A, Shimelis A. Household level determinants of food insecurity in rural areas of Dire Dawa, Eastern Ethiopia. AJFAND Online. 2009;9(9):1914-1926.
25. FAO (Food and Agriculture Organization). Agro-ecological zoning guidelines. FAO Soils Bulletin 73; 1996.
26. CTA/ECSA (Technical Centre for Agricultural and Rural Cooperation/ East, Central and Southern African Food and Nutrition Cooperation). Food composition table. The Netherlands: Wegeningen Agricultural University, Department of Human Nutrition; 1987.
27. FAO. Human energy requirement. Report by a Joint FAO/WHO/UNU Expert Consultation, Rome; 2001.
28. Djebou SDC, Price E, Kibriya S, Ahn J. Comparative analysis of agricultural assets, incomes and food security of rural households in Ghana, Senegal and Liberia. Agriculture. 2017;7(5):38.
29. Helfand SM, Levine ES. Farm size and determinants of productive efficiency in Brazilian Centre West. Agricultural Economics. 2004;31:241-249.
30. Padilla-Fernandez MD, Nuthall PL. Farm size and its effect on the productive efficiency of sugar cane farms in Central Negros, the Philippines. J. ISSAAS. 2012;18(1):49-61.
31. Gorton M, Davidova S. Farm productivity and efficiency in the CEE applicant countries: A synthesis of results. Agricultural Economics. 2004;30:1-16.

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