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Do food security indicators vary between male and female-headed households? Evidence from legume farmers in Western Kenya

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Introduction: Food security is an important aspect of sustainable development at global, national and local levels. However, differences in resource endowments and control thereof, may privilege some households and regions than others. As a result, households' diets may be varied leading to differences in food security status. Various initiatives that seek to diversify diets through legume integration on farms have been promoted in developing countries; but, their effects on household food security remains undocumented. In order to address the above knowledge gap, this study compares the food security indicators of male and female-headed households that integrate legumes in their farms in Nandi County, Kenya.

Methods: Using cross-sectional data from 374 respondents, various food security scores were computed. Subsequently, the ordinary least squares regression model was applied to determine factors that influence the food security scores.

Results and discussion: The results revealed that the food security scores were in the normal range; acceptable food consumption score of 62.20 and medium household dietary diversity score of 5.24. In both the male- and female-headed households; land size, access to credit and distance to nearest open-air market from the household significantly affected food security scores positively, while number of meals per day had significant negative effect. Further, in the male-headed households, the food security score was positively affected by household size and years of farming experience, while the household head's age negatively affected the food security score. These findings provide useful insights on the need to target specific interventions that support the attainment of desired levels of food security in male- and female-headed households based on their distinct levels of resource endowments and control.

KEYWORDS

food security score, legumes, Kenya, male headed household, female headed household

1 Introduction

Global food insecurity is a concern due to rapid increase in population, climate change and limited arable land. Food systems aim to produce enough nutritious food in environmentally sustainable ways while facilitating fair and equitable livelihoods, social justice and respect for cultural values (Marshall et al., 2021). However, environmental and social sustainability have often been compromised within food systems. Moreover, enough production may not always translate to affordability, accessibility or proper utilization of the food for healthy diets. Consequently, poverty, hunger and poor diet related diseases are on the rise, inequalities are extensively experienced, and environmental degradation has become a menace (Ambikapathi et al., 2022). The ongoing climate crisis highlights more than ever the need to diversify agri-food systems to more climate-smart ways of producing food, strengthening supply chains and improving diets, especially for farmers and low-income consumers in vulnerable regions (Ngigi et al., 2022). In this regard, legumes can be exploited as sustainable, climate change resistant and high-quality healthy protein sources. Grain legumes play an important role in increasing productivity in farming systems and improving food security in Sub Saharan Africa (SSA; Snapp et al., 2019). In Kenya, legumes are mostly intercropped with other cereals in push-pull technology systems aimed at controlling weeds and crop pests (Buleti et al., 2023). Intercropping cereals with multipurpose legumes improve soil fertility, increases crop yields and reduce chances of crop failure (Mupangwa et al., 2021).

Legumes can contribute to increasing the resilience of farming systems as they improve soil biodiversity and are crucial components of multiple cropping systems (Lal, 2017). For instance, they produce several compounds that feed soil microbes and benefit soil health especially by increasing the soil organic carbon (Lasisi and Liu, 2023) and as cover crops, they help in retention of soil moisture. Legumes fix nitrogen, a major crop nutrient, from the atmosphere into the soil, making it available to plants to increase productivity. In addition, they aid farmers to reduce use of synthetic fertilizers. Legume crops are also known to fight off plant disease-causing pests, thereby reducing dependency on chemical fertilizers and pesticides (Snapp et al., 2018; De Jager et al., 2019). Further, legumes produce a smaller carbon footprint, indirectly reducing greenhouse gas emissions. In most developing countries, legumes are grown as secondary crops with their potential being underutilized (Desire et al., 2021). Some legumes like *lablab* can be used as animal feeds for pigs, goats, sheep and cattle (Wangila et al., 2021). The legumes also improve the quality of manure from animals.

In recent food security debates, there is an increasing interest in proteins from plant sources as opposed to animal protein (Ismail et al., 2020; Perraud et al., 2022; Fouillet et al., 2023). Scientific evidence suggests that legume consumption reduces the risk of numerous chronic diseases (Conti et al., 2021) such as certain types of cancer, cardiovascular disease (CVD), and type 2 diabetes (Didinger et al., 2022). They also contain high levels of macro, micronutrients and bioactive metabolites with synergic effect against inflammation, which plays a role in disease onset or progression (Zhu et al., 2018). This means they are suitable for human health (particularly pregnant mothers) and young children as they offer a cheap and affordable source of protein and serve to prevent malnutrition. As noted by Sharma et al. (2022) legumes contain twice the amount of protein found in whole grain cereals. Legumes also maintain their high nutritional value even when stored for a long period (Singh et al., 2022). This trait is particularly valuable for smallholder farmers who depend on the food they store between harvests.

The Food and Agriculture Organization of the United Nations (FAO) supports a Strategic Framework 2022–2030 for sustainable agri-food systems anchored on “Four Betters” (FAO, 2022), that is, better production, better nutrition, better environment and better life. Legumes perfectly fit into this paradigm due to their characteristics. They come with many advantages to human nutrition and environment. Low dietary diversity is one of the major causes of malnutrition in Kenya. As a result, the government and other partners have been promoting the uptake of plant-based legumes such as groundnuts, dolichos *lablab*, soya bean and common bean in order to address the rising cases of poor nutrition (Okelloh et al., 2023) in different parts of the country. Unfortunately, their consumption remains low at 25 g/day in sub Saharan Africa against the potential level of 50 g/day recommended by the EAT—Lancet Commission on food, planet and health (Willett et al., 2019). In Kenya, common bean is the most cultivated and consumed legume. Bean consumption is estimated at 14 kg per year but it can go up to 66 kg per year in the western part of the country (Nduati et al., 2023), where there are high incidences of poor dietary diversity despite existence of multiple food crops.

Farmers in these regions have been introduced to diverse ways of legume consumption to increase its nutritional benefit. For instance, porridge flour made from legumes and other cereals has been promoted (Gitau et al., 2019). Moreover, some legumes are baked into snacks, others roasted and some taken as soups and stews. Despite the enormous potential of legumes to contribute to household diets and better nutrition, the level of food security among households that integrate the legumes has not been fully documented; more so on a gender dimension.

This study therefore explores the dimensions of food security in male- and female-headed households in Nandi County, Western Kenya in relation to legumes. Nandi County is relevant to this study because of its high level of depletion of soil fertility (Njoroge and Zingore, 2017). In addition, Nandi County experiences incidences of food insecurity and malnutrition [Nandi County Integrated Development Plan (NCIDP), 2023]. Legumes can be used to reclaim the lost soil fertility in this region as it improves soil health. In addition, farmers in this region are less resource endowed making them vulnerable to food insecurity and malnutrition. Therefore, the idea of legume integration in this region came in handy considering its multi-purpose nature. Employing agro-ecological principles in this region using legumes ensures a circular economy while sustaining the farmers’ resource levels (Bezner Kerr et al., 2019). Socio-cultural heterogeneity in Nandi County [Nandi County Integrated Development Plan (NCIDP), 2023] affects utilization and preferences for legumes among the male and female members. Therefore, this study contributes to the knowledge gap around dietary diversity in male and female-headed households. Further, the study builds on the suggested area for further research by Amoah et al. (2023), on gender-specific factors associated with legumes consumption.

2 Methodology

2.1 Study area, sampling procedure, and data collection

The study was conducted in Nandi County, western Kenya (Figure 1). According to the national census data, Nandi County has a total population of 885,711 (KNBS, 2019), with a land area of 2,884.4 Km^2 and population density of 310 persons per Km^2. Due to the high population, there has been land fragmentation and continuous

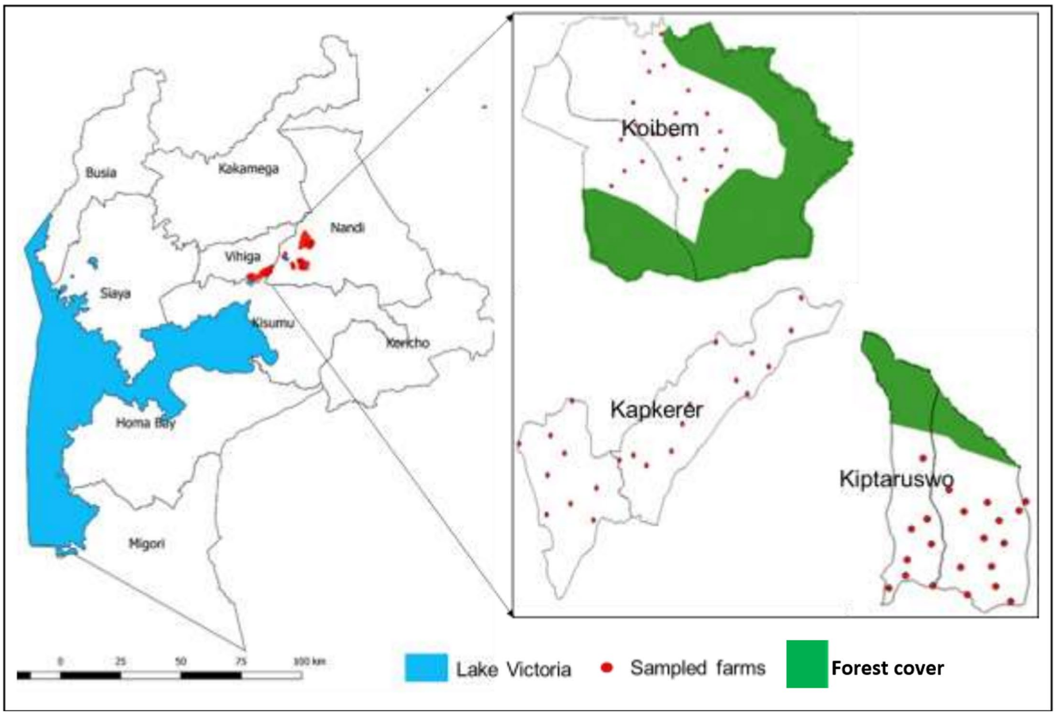

FIGURE 1
Map of Nandi County, Kenya.

cropping in the region, leading to the depletion of the natural resource base, malnutrition and increased poverty levels.

A three-stage sampling technique was employed; in the first stage, Nandi County was purposively selected since it is an experimental site for a legume integration project. In the second stage, stratified sampling was applied to select three sub-countries in Nandi (Koibem, Kiptaruswo, and Kapkerer). The selection of both the County and three sub-counties were based on the fact that legume options had been rolled out in the regions by the collaborative crops research program (CCRP). In the third stage, systematic random sampling was used to select households. A starting point was identified from a list given by the local extension officer, then every 5th household was selected from the list. The choice of every 5th household was to avoid selection bias of very close relatives.

Focus group discussions (FGDs), one in each of the three sub-counties, were conducted to help identify issues around food security in households integrating legumes. The issues identified included; legume management at the farm, legume utilization within the households, legume marketing and the influence of legumes on food security. The issues identified were later used in designing the survey tool. The selection criteria for the FGD participants included sex and age group; with 6 male and 6 female participants in each group. All the participants were farmers who integrated legumes in their farming systems. In addition, there was a balance between the old and the young in the groups for both sexes. The young were defined as those below 40 years, while the old were defined as those above 40 years old. The FGDs comprised 12 members each, which is the acceptable number for an FGD.

A follow-up household survey was conducted after the FGDs through face-to-face interviews, which guarantee high response rates besides enabling clarification of survey questions in interviews. The survey used semi-structured questionnaires to collect data on the cultural, socio-economic and institutional characteristics. Data collection was done using a pretested, semi-structured questionnaire programmed in Open Data Kit (ODK).

The formula adapted from Fisher (1983) was used to calculate a reasonable sample size for the study (Equation 1).

$$n = \frac{z^2 (p)(q)}{d^2} \tag{1}$$

where,

n, the desired sample size (if the target population is greater than 10,000);

Z, the critical *z*-value at the required confidence interval;

P, the proportion in the target population estimated to have integrated legumes;

q, 1 – *P;*

d, confidence interval or statistical significance.

$$n = \frac{1.96^2 (0.5)(0.5)}{0.05^2} = 384$$

A value of *p* of 0.5 was used with an assumption of maximum variability in the population. In addition, assuming a normal distribution, a confidence interval of 95% covered representation of extreme values (Singh and Masuku, 2012). Further, a corresponding *Z*-value of 1.96 was used. Due to potential challenges of non-responses and incomplete questionnaires since data was collected during the advent of Covid-19, where movements were restricted, the calculated sample size was adjusted upwards by 10% in line with the suggestions of Israel (1992) to 423. However, after data cleaning, the valid sample size dropped to 374 households. The data cleaning and analysis were done in Excel and STATA version 14.1 software.

2.2 Conceptual framework

The conceptual framework (Figure 2) was adapted from Kanter et al. (2015) which shows the links between agriculture, food, nutrition and health. The key theme for this framework is on 'gender' and 'household quality care' which are related to household activities and dietary diversity. A modification was made on the framework to cover only aspects of the relationships between agriculture, food and nutrition since the study focused on dietary diversity. The framework begins from the point of 'input and innovation' where a farmer is exposed to different technological and agricultural practices that include integration of legumes in the farming systems. It then follows a primary agricultural production line where the farmers' interest is on the quality produced, quantity produced, diversity within the farming systems and farm gate prices. Once production is completed, farmers have the liberty to choose whether to store and consume the products, sell the products and get income or channel them to non-agricultural enterprises. Should farmers choose to produce and consume, then they need to worry about food availability, diversity, nutrition quality and food prices outside what they produce. The ultimate focus is on individual or population consumption which influences household quality care in terms of feeding, education and knowledge on consumption, time to participate in agricultural production, and knowledge on the nutrition and dietary diversity. Gender is specifically referenced in the household quality of care domain of the framework because gender roles considerably influence nutrition pathways and outcomes. The framework posits that the role and impact of female empowerment is deeply rooted within the household where decision-making occurs around food acquisition, income and dietary sources.

2.3 Measurement of food security

Food security can be measured using different indicators: household dietary diversity score (HDDS), food consumption score (FCS), coping strategy index (CSI), household food insecurity access scale (HFIAS) and months of adequate household food provisioning (MAHFP). The CSI and HFIAS capture accessibility and stability dimension of food security (Maxwell et al., 2013) while MAHFP captures food availability and stability dimensions (Bilinsky and Swindale, 2010). However, this study focused on measuring dietary diversity which are outside the scope of CSI, HFIAS and MAHFP. Therefore, this study adopted HDDS and FCS, which are not only composite measures of dietary diversity but also capture frequency of food consumption and nutritional importance (Vhurumuku, 2014). Further, the two indicators capture the utilization dimension of food security (Bilinsky and Swindale, 2010).

Table 1 illustrates calculations and classifications of HDDS and FCS adapted from Mutea et al. (2019). The HDDS is calculated by summing up equally weighted response data on the consumption of 12 food groups (i.e., cereal grain staples, roots and tubers, vegetables, fruits, meat, eggs, fish, legumes and nuts, dairy products, oils and fats, sugar, and condiments). The respondent was asked if anyone in the household consumed any item from each food group in the previous 24h. These responses were summed up to obtain a score from 0 to 12 (Jones et al., 2013).

The FCS uses a seven-day food frequency data, grouping all food items into 9 food groups (i.e., staples, vegetables, fruits, meat and fish, legumes, milk, oils, and sugar and condiments). The seven-days for this study was with reference to a week before data collection. Consumption frequencies for the same food groups were summed up. The value obtained was multiplied for each food group by its weight to create a new weighted food group scores (Vhurumuku, 2014). The

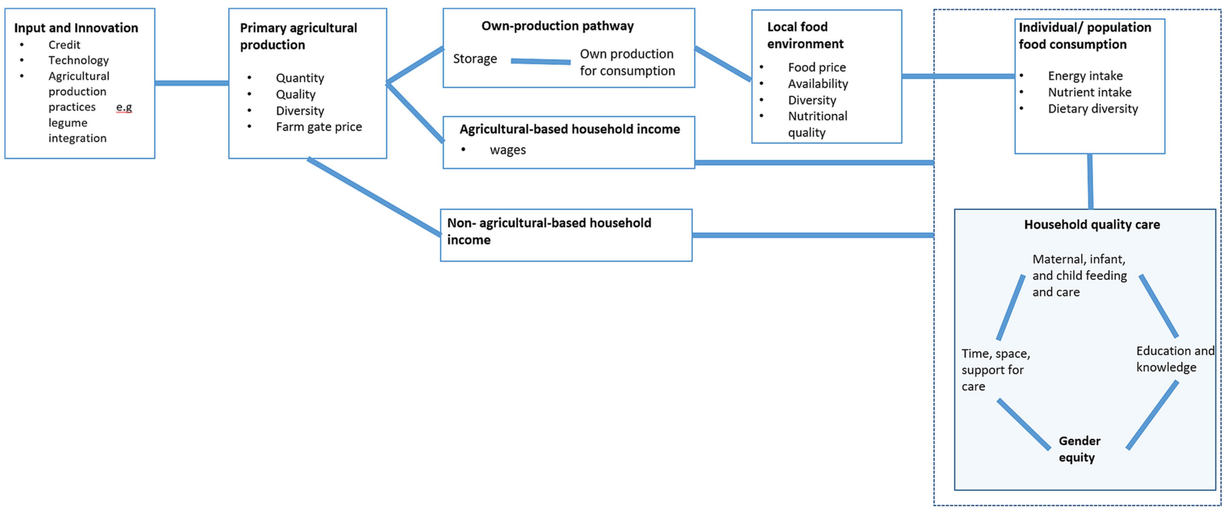

FIGURE 2
Conceptual framework.

TABLE 1 Calculation and classification of each food security indicator.

Food security indicator	Calculation guidelines	Classification guidelines	References
Household dietary diversity score	Grouping foods into 12 categories, i.e., cereals, white tubers and roots, vegetables, fruits, meats, eggs, fish and other sea foods, legumes, nuts and seeds, milk and milk products, oils and fats, and sweets, spices, condiments, and beverages. The responses should either be "0" or "1." Summing all the food groups should be able to give a household dietary score ranging from 0 to 12.	≤3 food groups = Lowest dietary diversity	WFP (2008)
		4 and 5 food groups = Medium dietary diversity	
		≥6 food groups = High dietary diversity	
Food consumption score	Grouping of foods into 9 categories, i.e., staples, vegetables, fruits, meat and fish, pulses, milk, oils, and sugar and condiments. Each group is then multiplied by its weight. The guiding principle to determine the weight is the nutrient density of the food groups. Staples = 2, vegetables = 1, fruits = 1, meat and fish = 4, pulses = 3, milk = 4, oils = 0.5, sugar = 0.5 and condiments = 0. Summing all the food groups provides a household food consumption score.	0–21 = Poor food consumption score	WFP (2008)
		21.5–35 = Borderline food consumption score	
		>35 = Acceptable food consumption score	

weighted food group scores were then summed up to obtain the FCS that ranged between 0 and 112 (WFP, 2008).

2.4 Analysis of food security scores

Data was analyzed and standardized as required. For example, livestock ownership was converted to tropical livestock units (TLUs) by a factor (cattle = 0.7, goats/sheep = 0.1, poultry = 0.01) according to Rothman-Ostrow et al. (2020). Means and standard deviations of the key variables were calculated and tabulated by the gender of the household head. The FCS and HDDS were computed using the international standards for food security as per the food and nutrition technical assistance for communities (FANTA) document (WFP, 2008). The FSS was given as a summation of FCS and HDDS for the households (Equation 2). The summation of the FCS and HDDS to create a composite measure is guided by the logic that food security cannot be measured independently using one measure.

$$x_n^{FSS} = \left(z_n^{FCS} + z_n^{HDDS} \right) \tag{2}$$

where, x_n^{FSS}, z_n^{FCS}, and z_n^{HDDS} are composite food security score, food consumption score, and household dietary diversity score, respectively for the nth household.

Since FCS and HDDS measure similar aspects on dietary diversity (Jones et al., 2013) with a close relevance of the recall questions asked on food consumption, they are likely to be correlated. Therefore, this study used a spearman's *rho* correlation to test the correlations (Mutea et al., 2019) between FCS, HDDS and FSS.

Considering that the FSS obtained was a continuous variable, an ordinary least squares (OLS) regression, which has also been used in previous food security studies (Bhalla et al., 2018; Coulibaly et al., 2023), was employed to analyze the factors affecting FSS between the male-headed households (MHHs) and the female-headed households (FHHs). In the OLS regression specified, (Equation 3) represents the response variable as a function of different regressors. Equation 4 introduces the intercept, and the unobserved random error accounting for influences upon the response variable other than the regressors. Equation 5 represents the linear model used to determine the response variable. male-headed households (MHHs) and the female-headed households (FHHs).

The OLS regression model was specified below:

$$Y = X_1 + X_2 + X_3 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{10} \tag{3}$$

$$Y = \alpha + i \sum X + \mu \tag{4}$$

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots + \beta_{10} X_{10} + \ldots\ldots\ldots\ldots + \mu \tag{5}$$

where,
Y = Composite FSS
α = Constant
β = Coefficients of the specific variables shown in Table 2
μ = error term.

3 Results and discussion

3.1 Descriptive statistics

Table 3 presents the characterization of key household demographics. About two-third of the interviewed households were male-headed. The finding is in agreement with other studies conducted in the same region by Onyango (2019) and Nyamasoka-Magonziwa et al. (2021) who found most of the households to be MHHs. The average age of the household head in FHHs was higher than in the MHHs. Nevertheless, in both categories, the household heads' ages were below that of an average farmer in Kenya; 60 years against a life expectancy of 65 years [Ministry of Agriculture, Livestock and Fisheries (MoALF), 2018]. The pooled average age of 49 years is an indication that younger persons were also involved in farming. The analysis also showed that slightly more than half of the household heads had completed primary education.

The FHHs had more farming experience than MHHs. Apart from farming activities, men are more likely to be engaged in other off-farm activities like formal employment as opposed to women. This makes men have less time to concentrate on farming activities unlike the women, hence the more years of farming

TABLE 2 Description of variables included in the OLS regression.

Variable	Measurement of variables	Expected sign
Age (X_1)	Age in years of the household head	+/−
Years of schooling (X_2)	Number of years completed in formal school	+
Household size (X_3)	The total number of people who live and feed in the household at the time of data collection	−
Farm experience (X_4)	Years of experience in general farming	+
Land size (X_5)	Total farming land in acres	+
Farm income (X_6)	Income from farming in Kenyan shillings (KES)	+
Livestock ownership (TLUs) (X_7)	Tropical livestock Units (TLUs) conversions	+
Meals per day (X_8)	Number of times meals are eaten per day	+
Access to credit (X_9)	Dummy (1 = Yes, 0 = No)	+
Distance from the homestead to the nearest open-air market (X_{10})	Average distance from the homestead to the nearest open air market (Km)	−

TABLE 3 Household characteristics.

Variables	FHHs (*n* = 129)		MHHs (*n* = 245)		Pooled (*n* = 374)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	52.42	12.97	47.67	13.54	49.31	13.52
Years of schooling	6.06	4.87	8.83	5.61	7.88	5.52
Never went to school (%)	6.20	3.04	6.53	2.23	6.42	1.80
Primary education (%)	56.59	4.38	56.33	3.18	56.42	2.57
Secondary education (%)	25.58	3.86	26.12	2.81	25.94	2.27
Tertiary education (%)	11.63	2.83	11.02	2.00	11.23	1.63
Household size	5.09	2.94	4.99	2.25	5.03	2.51
Farm experience (years)	24.00	15.20	18.85	12.87	20.63	13.92
Land size (acres)	1.26	1.26	1.39	1.49	1.34	1.42
Annual farm income in 1000 (KES	151.19	116.07	131.27	100.03	138.14	106.11
Livestock ownership (TLUs)	0.66	0.79	0.86	0.99	0.79	0.93
Meals per day	2.64	0.57	2.75	0.48	2.71	0.52
Access to credit (%)	32.60	24.90	42.90	3.20	39.30	2.50
Distance to the nearest open-air market	4.06	3.42	4.07	3.22	4.07	3.29

SD represents standard deviations. Source: Survey Data (2021).

experience in FHHs than MHHs. Moreover, FHHs having more time on farming partly explain why they generated more income from farming than MHHs. The MHHs had larger acres of land than FHHs. This corroborates the assertion in the FGD that land ownership is culturally skewed toward men among the communities in Nandi County. A similar trend was also recorded by Wudil et al. (2022) that only 12% of women in Sub Saharan Africa own land as sole owners. Further, 42% of MHHs had access to credit as opposed to a third of FHHs. The main sources of credit for legume farmers in the study site were friends, relatives, and neighbors; informal savings and credit groups particularly women group/table banking/merry go round as opposed to formal microfinance institutions and commercial banks.

The average TLU was 0.66 for FHHs and 0.86 for MHHs. Every household reported having had at least two meals per day in the previous week. This corroborates the findings of Keya et al. (2019) who found that 57.1% of households in Kenya take two meals on average and that reducing number of meals is a coping strategy for most poor households who find food market prices expensive. The distance from homesteads to the nearest open-air market was approximately 4 km.

3.2 Food security scores

Table 4 shows different food security scores between the FHHs and the MHHs that grow legumes. The HDDS, FCS and FSS were

TABLE 4 Indicators of food security score.

FSS indicators	FHHs (n = 129)	MHHs (n = 245)	Pooled sample (n = 374)	Test for statistical differences in means between MHHs and FHHs (t-ratio)
HDDS	5.16	5.28	5.24	0.57
FCS	60.93	62.88	62.20	1.02
FSS	66.08	68.16	67.45	0.99

Source: Survey Data (2021).

TABLE 5 Spearman's correlation coefficients between HDDS, FCS, and FSS.

	HDDS	FCS	FSS
HDDS	1.000	-	-
FCS	0.757***	1.000	-
FSS	0.794***	0.998***	1.000

***Represents 1% statistical significance level. Source: Survey Data (2021).

generally higher in MHHs than FHHs; though the differences were statistically insignificant. This is contrary to Muthini et al. (2020) who found the dietary diversity of MHHs to be higher than in FHHs. At least 5 out of the 12 food groups were consumed by both categories of the households and they also had acceptable FCS of above 35. However, it is worth noting that higher and acceptable FCS above 35 may not always reveal how food secure a household is. Ideally, some households may have consumed foods that are at the borderline that cumulatively give a higher score. For example, a household that consumed milk (FCS score of 4) for breakfast, vegetables (FCS score of 1) for lunch, and staples (FCS score of 2) for supper, gets a lower FCS than a household that consumes legumes (FCS score of 3) for the three meals. According to the FCS score scale, the second household is considered better than the first one; an observation that is contrary to expectations from the nuances in food security. The first household achieves diversity of foods and balanced diets while the second household is likely to suffer from malnutrition since it maintains the same food group. Therefore, FCS is considered a conservative indicator and may not always reflect the real dimension of food insecurity within the households (WFP, 2008).

Considering that HDDS and FCS are correlated, a spearman's correlation coefficient was computed between the two and the composite FSS to determine the strengths of the correlations (Table 5). At a 1% level of significance, the FCS and HDDS were strongly correlated. This was expected given the nature of similar questions asked for the food intake data (Vaitla et al., 2017) with a slight difference on the recall period. The composite FSS was strongly correlated with both HDDS and FCS at 0.794 and 0.998, respectively.

3.3 Factors influencing food security scores

Table 6 presents results of the OLS regression on factors that affect FSS between FHHs and MHHs. The overall pooled results of the OLS regression showed a significant OLS equation with $F(10, 363) = 13.65$, value of p associated with the F test (0.0000), and adjusted R^2 of 0.25. Farm experience, land size, access to credit, and distance to the nearest open air market had positive effects on the FSS at 1% level of significance. However, at the same level of significance meals per day had a negative effect on FSS. In addition, age had a negative effect on the FSS at 5% level of significance.

The number of meals taken per day negatively affected FSS in both FHHs and MHHs. This can be attributed to monotonous diets eaten throughout the day. Penafiel et al. (2022) in a study on healthy eating in Western Kenya concluded that dietary diversity is linked to consuming a variety of food in meals throughout the day. This was contrary to the expected results where it was hypothesized that more meals taken per day would increase the nutrient density hence higher FSS scores. This result also contradicts the findings in Ethiopia by Huluka and Wondimagegnhu (2019), which indicated that frequency of meals taken per day was positively related with HDDS. Legumes play a significant role in diets contributing to about 10 to 40% of protein consumption in Sub-Saharan Africa (Ngigi et al., 2022). The forms of legume consumption include; cooked legumes for stew, fried, eaten in porridge flour and baked for snacks (FGD). However, proteins alone cannot contribute to the overall FSS. As the number of meals increase, households should also be keen to include the other food groups like vegetables and carbohydrates in their diets for a balanced diet, and increased FSS.

An increase in age of the household head in the MHHs reduced the FSS. This is due to reduced consumption of legumes in MHHs. Legumes often require long time for sorting, cooking and more fuel for cooking, hence may be undesirable for MHHs (Wood, 2017). The results are contrary to those of Korir et al. (2021) which reported an increase in food security with an increase in age in Kenya. The contradiction emanates from the fact that the study separates FHHs and MHHs. In addition, Korir et al. (2021) used an entitlement approach to measure food security while the current study used dietary diversity scores. Nevertheless, the results of this study are similar to those of Kumar et al. (2020) which showed that age negatively correlated with dietary diversity in Nepal. Among the FHHs, age positively influenced FSS but was insignificant.

Farm experience increased FSS in MHHs. With more farm experience, one acquires more knowledge and is able to diversify their farming systems. Globally, legume production is done in marginalized regions on infertile grounds while the fertile grounds are left for cereals (Popoola et al., 2022). Similarly, the regions in Nandi County where legumes are grown suffer loss of the natural resource base, which makes it hard increase legume productivity. As farmers in the MHHs gain experience, they get well versed with the right technologies and practices to employ in legume production. Consequently, they get to understand the inherent useful agronomic, genetic and biochemical traits of legumes. Further, increased legume integration generates more revenue, and more consumption eliminates micronutrient and protein deficiencies in diets (Khan et al., 2021). This results to balanced diets and food diversification leading to increased FSS.

Land size positively affected FSS in both the MHHs and the FHHs. Those with larger farms integrated multiple varieties of legumes in

TABLE 6 OLS regression results on factors affecting FSS.

Variables	FHHs (n = 129)		MHHs (n = 245)		Pooled (n = 374)	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Age (years)	0.046	0.161	−0.325***	0.116	−0.188**	0.094
Years of schooling (years)	−0.116	0.319	0.025	0.190	0.027	0.161
Household size	−0.654	0.524	1.224**	0.495	0.318	0.359
Farm experience (years)	0.204	0.136	0.363***	0.120	0.284***	0.090
Land size (acres)	2.594**	1.224	2.318***	0.754	2.516***	0.644
Livestock ownership (TLUs)	−1.925	1.953	0.194	1.070	−0.275	0.941
Number of meals per day	−4.978*	2.664	−7.671***	2.269	−6.575***	1.713
Access to credit (1 = Yes)	8.516***	3.214	4.336**	2.178	5.975***	1.814
Distance from homestead to the nearest open-air market (Km)	2.043***	0.457	1.558***	0.341	1.735***	0.274
Constant	63.079***	11.241	84.706***	8.917	77.373***	6.891

***, **, * denote statistical significance at 1%, 5%, and 10%, respectively. Source: Survey Data (2021).

their farms. These legumes were planted based on particular niches for example; for food, feed, weed control, for sale among other purposes. This implies resilience of the households in times of climate and market fluctuations. With such resilience and diversity, households are able to maintain sustainable agricultural systems where legumes play a key role and high food security scores. These results align with those of Mudzielwana et al. (2022) who found land positively relating to food security among irrigation farm workers in South Africa.

Access to credit had a positive effect on both the FHHs and MHHs' food security scores. Farmers used part of the credit to obtain more improved legume seeds other than the landraces to incorporate into their farming systems. In addition, with increased access to credit they were also able to try new legume technologies and amendments. This contributed to increased productivity, which improved access to food within the households, and more income for households that were able to commercialize. Further, extra income from the credit could be used to purchase extra food and meet production deficits (Mutea et al., 2019) thus increasing dietary diversity. Similar results were reported by Ingutia and Sumelius (2022) in the Western part of Kenya where access to credit increased food security among female farmers. In addition, Acheampong et al. (2022) in Ghana found that an increase in credit increased use of purchased production inputs, which positively contributed to food security.

An increase in household size increased FSS in MHHs. This was contrary to expectation. A plausible explanation for this can be the fact an extra household member provides more labor for farming. Thus, increasing efficiency in production, and maintaining levels of food consumption, resulting to increased FSS. This conforms to Jones et al. (2013) who found household size to positively influence HDDS. Contrary results in Ethiopia (Fikire and Zegeye, 2022), and South Africa (Abegunde et al., 2022) reveal that increasing the household size increased dependency and in turn increases food insecurity.

As distance increased away from the nearest open-air markets, both the male and female headed households were likely to be food secure. Limited market access tend to divert the attention of farmers toward subsistence farming in maintaining their food reserves (Muthini et al., 2020). Open-air markets are quite far at about 4 kilometers from the homesteads in Nandi County. This enables farmers to be more innovative in their cropping. Legumes are intercropped with other cereals and tubers. This helps in increasing nitrogen context in the soils for other crops. In addition, they help prevent some weeds like *striga*. More healthy crops imply diversified diets, increased availability and better access to food, resulting positively to improved FSS. However, these results are contrary to those of Manda et al. (2018) who found that an increase distance to the market had negative impact on food security in Zambia.

4 Conclusion and recommendations

This study has demonstrated that on average, households had medium dietary diversity scores and acceptable level food consumption scores; an indication that the sampled households were not badly off in terms of food utilization in both male-headed and female-headed households. The main determinants of food security score were land size, access to credit and distance to the nearest open-air market.

Based on the findings of this study, policy interventions that are geared toward diversification of legume options in the farming systems according to the farmer's needs are suggested. Since legumes fetch higher prices in the market, the county government of Nandi should link farmers with ready markets to help them get more income. This can be done through contract farming between the farmers and the county government entity responsible. When farmers have more income, they will be able to buy other food crops not produced within their farms to maintain their nutritional food status.

Through the county health extension agents, programs to enlighten farmers on different ways of legume preparation should be advocated. This will ensure that legumes are consumed in a more palatable way, without any stomach discomforts. Due to gender implications, innovative but simple ways of processing legumes should be adopted to stir up consumption. These include advocating for development of and improving access to less-time consuming equipment and methods for value addition on legumes; for instance portable locally-made shelling equipment.

This study was limited to dietary diversity. Future studies should cover the composite FSS using the other food security indicators not included in this study; CSI, HFIAS and MAHFP, which would provide insights on other dimensions of food security. Considering the other measurements of food security will give a more concrete conclusion on food security status. Further insights can also be derived from a comprehensive analysis of the effect of various factors on food security indicators in different agro-ecological zones.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

SO: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – original draft, Writing – review & editing. DO: Conceptualization, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing. EC: Conceptualization, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – review & editing. JO: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

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References

Abegunde, V. O., Sibanda, M., and Obi, A. (2022). Effect of climate-smart agriculture on household food security in small-scale production systems: a micro-level analysis from South Africa. *Cogent Soc Sci* 8:2086343. doi: 10.1080/23311886.2022.2086343

Acheampong, P. P., Obeng, E. A., Opoku, M., Brobbey, L., and Sakyiamah, B. (2022). Does food security exist among farm households? Evidence from Ghana. *Agric Food Secur* 11, 1–13. doi: 10.1186/s40066-022-00362-9

Ambikapathi, R., Schneider, K., Davis, B., Herrero, M., Winters, P., and Fanzo, J. C. (2022). Global food systems transitions have enabled affordable diets but had less favourable outcomes for nutrition, environmental health, inclusion and equity. *Nat Food* 3, 764–779. doi: 10.1038/s43016-022-00588-7

Amoah, I., Ascione, A., Muthanna, F., Feraco, A., Camajani, E., Gorini, S., et al. (2023). Sustainable strategies for increasing legume consumption: culinary and educational approaches. *Foods* 12:2265. doi: 10.3390/foods12112265

Bezner Kerr, R., Hickey, C., Lupafya, E., and Dakishoni, L. (2019). Repairing rifts or reproducing inequalities? Agroecology, food sovereignty, and gender justice in Malawi. *J. Peasant Stud.* 46, 1499–1518. doi: 10.1080/03066150.2018.1547897

Bhalla, G., Handa, S., Angeles, G., and Seidenfeld, D. (2018). The effect of cash transfers and household vulnerability on food security in Zimbabwe. *Food Policy* 74, 82–99. doi: 10.1016/j.foodpol.2017.11.007

Bilinsky, P., and Swindale, A. (2010). *Months of adequate household food provisioning (MAHFP) for measurement of household food access: indicator guide (version 4).* Washington, DC: FHI, 360.

Buleti, S., Kuyah, S., Olagoke, A., Gichua, M., Were, S., Chidawanyika, F., et al. (2023). Farmers' perceived pathways for further intensification of push-pull systems in Western Kenya. *Front Sustain Food Syst* 7:1191038. doi: 10.3389/fsufs.2023.1191038

Conti, M., Guzzetti, L., Panzeri, D., De Giuseppe, R., Coccetti, P., Labra, M., et al. (2021). Bioactive compounds in legumes: implications for sustainable nutrition and health in the elderly population. *Trends Food Sci. Technol.* 117, 139–147. doi: 10.1016/j.tifs.2021.02.072

Coulibaly, A., Macalou, M., Keita, S., and Diamoutene, A. (2023). Urbanization and food security: evidence from Mali. *Front Sustain Food Syst* 7:1168181. doi: 10.3389/fsufs.2023.1168181

De Jager, I., Borgonjen-Van Den Berg, K. J., Giller, K. E., and Brouwer, I. D. (2019). Current and potential role of grain legumes on protein and micronutrient adequacy of the diet of rural Ghanaian infants and young children: using linear programming. *Nutr. J.* 18, 12–16. doi: 10.1186/s12937-019-0435-5

Desire, M., Blessing, M., Elijah, N., Ronald, M., Agather, K., Tapiwa, Z., et al. (2021). Exploring food fortification potential of neglected legume and oil seed crops for improving food and nutrition security among smallholder farming communities: a systematic review. *J Agri Food Res* 3, 100117–100128. doi: 10.1016/j.jafr.2021.100117

Didinger, C., Foster, M., Bunning, M., and Thompson, H. (2022). "Nutrition and Human Health Benefits of Dry Beans and Other Pulses," in *Dry Beans and Pulses*. Eds M. Siddiq and M. Uebersax. doi: 10.1002/9781119776802.ch19

FAO (2022). *Digital innovation strategy for agrifood systems in Africa – Abridged version 2021–2025.* Accra. doi: 10.4060/cb8305en

Fikire, A. H., and Zegeye, M. B. (2022). Determinants of rural household food security status in north Shewa zone, Amhara region, Ethiopia. *Scientific World J* 2022:1063. doi: 10.1155/2022/9561063

Fisher, R. V. (1983). Flow transformations in sediment gravity flows. *Geology* 11, 273–274. doi: 10.1130/0091-7613(1983)11<273:FTISGF>2.0.CO;2

Fouillet, H., Dussiot, A., Perraud, E., Wang, J., Huneau, J. F., Kesse-Guyot, E., et al. (2023). Plant to animal protein ratio in the diet: nutrient adequacy, long-term health and environmental pressure. *Front. Nutr.* 10:1178121. doi: 10.3389/fnut.2023.1178121

Gitau, P. W., Kunyanga, C. N., Abong, G. O., Ojiem, J. O., and Muthomi, J. W. (2019). Assessing sensory characteristics and consumer preference of legume-cereal-root based porridges in Nandi County. *J. Food Qual.* 2019, 1–7. doi: 10.1155/2019/3035418

Huluka, A. T., and Wondimagegnhu, B. A. (2019). Determinants of household dietary diversity in the Yayo biosphere reserve of Ethiopia: an empirical analysis using sustainable livelihood framework. *Cogent Food Agric* 5:1690829. doi: 10.1080/23311932.2019.1690829

Ingutia, R., and Sumelius, J. (2022). Determinants of food security status with reference to women farmers in rural Kenya. *Scientific Afr* 15:e01114. doi: 10.1016/j.sciaf.2022.e01114

Ismail, B., Senaratne-Lenagala, L., Stube, A., and Brackenridge, A. (2020). Protein demand: review of plant and animal proteins used in alternative protein product development and production. *Anim. Front.* 10, 53–63. doi: 10.1093/af/vfaa040

Israel, G. D. (1992). *Institute of Food and Agriculture Sciences, EDIS*. Gainesville, FL: University of Florida Cooperative Extension Service.

Jones, A. D., Ngure, F. M., Pelto, G., and Young, S. L. (2013). What are we assessing when we measure food security? A compendium and review of current metrics. *Adv. Nutr.* 4, 481–505. doi: 10.3945/an.113.004119

Kanter, R., Walls, H., Tak, M., Roberts, F., and Waage, J. (2015). A conceptual framework for understanding the impacts of agriculture and food system policies on nutrition and health. *Food Secur* 7, 767–777. doi: 10.1007/s12571-015-0473-6

Keya, S. O., Kosura, W. O., Okeyo Mwai, A., and Kirina, T. K. (2019). Prospects for food security in Kenya: evidence from five counties. Available at: https://hdl.handle.net/10568/107053

Khan, M., Rafii, M., Ramlee, S., Jusoh, M., and Al Mamun, M. (2021). Genetic analysis and selection of Bambara groundnut (*Vigna subterranea* [L.] Verdc.) landraces for high yield revealed by qualitative and quantitative traits. *Sci. Rep.* 11:7597. doi: 10.1038/s41598-021-87039-8

KNBS, K. (2019). Kenya population and housing census volume I: population by county and Sub-County. Vol. I, 2019, Kenya National Bureau of Statistics.

Korir, L., Rizov, M., Ruto, E., and Walsh, P. (2021). Household vulnerability to food insecurity and the regional food insecurity gap in Kenya. *Sustainability* 13:9022. doi: 10.3390/su13169022

Kumar, A., Thapa, G., Mishra, A., and Joshi, P. (2020). Assessing food and nutrition security in Nepal: evidence from diet diversity and food expenditure patterns. *Food Secur* 12, 327–354. doi: 10.1007/s12571-019-01004-y

Lal, R. (2017). Improving soil health and human protein nutrition by pulses-based cropping systems. *Adv. Agron.* 145, 167–204. doi: 10.1016/bs.agron.2017.05.003

Lasisi, A., and Liu, K. (2023). A global meta-analysis of pulse crop effect on yield, resource use, and soil organic carbon in cereal-and oilseed-based cropping systems. *Field Crop Res* 294:108857. doi: 10.1016/j.fcr.2023.108857

Manda, J., Gardebroek, C., Kuntashula, E., and Alene, A. D. (2018). Impact of improved maize varieties on food security in eastern Zambia: a doubly robust analysis. *Rev. Dev. Econ.* 22, 1709–1728. doi: 10.1111/rode.12516

Marshall, Q., Fanzo, J., Barrett, C., Jones, A., Herforth, A., and McLaren, R. (2021). Building a global food systems typology: a new tool for reducing complexity in food systems analysis. *Front Sustain Food Syst* 5:746512. doi: 10.3389/fsufs.2021.746512

Maxwell, D., Jennifer, C., and Bapu, V. (2013). How Do Different Indicators of Household Food Security Compare? Empirical Evidence from Tigray. Feinstein International Center, Medford, USA: Tufts University.

Ministry of Agriculture, Livestock and Fisheries (MoALF) (2018). "Irrigation" in *Kenya youth agribusiness strategy 2018–2022 (MoALF), Kilimo Nairob*.

Mudzielwana, R., Mafongoya, P., and Mudhara, M. (2022). An analysis of the determinants of irrigation farmworkers' food security status: a case of Tshiombo irrigation scheme, South Africa. *Agriculture* 12:999. doi: 10.3390/agriculture12070999

Mupangwa, W., Nyagumbo, I., Liben, F., Chipindu, L., Craufurd, P., and Mkuhlani, S. (2021). Maize yields from rotation and intercropping systems with different legumes under conservation agriculture in contrasting agro-ecologies. *Agric. Ecosyst. Environ.* 306:107170. doi: 10.1016/j.agee.2020.107170

Mutea, E., Bottazzi, P., Jacobi, J., Kiteme, B., Speranza, C., and Rist, S. (2019). Livelihoods and food security among rural households in the north-western Mount Kenya region. *Front Sustain Food Syst* 3:462897. doi: 10.3389/fsufs.2019.00098

Muthini, D., Nzuma, J., and Qaim, M. (2020). Subsistence production, markets, and dietary diversity in the Kenyan small farm sector. *Food Policy* 97:101956. doi: 10.1016/j.foodpol.2020.101956

Nandi County Integrated Development Plan (NCIDP) (2023). *County integrated development plan 2023–2027*. County Government of Nandi, Kenya.

Nduati, T. W., Wagara, I. N., Walyambillah, W., Were, B., and Matasyoh, J. C. (2023). Bioactive compounds from Juniperus procera (Cupressaceae) with activity against common bean bacterial pathogens. *Afr. J. Biotechnol.* 22, 106–113. doi: 10.5897/AJB2023.17552

Ngigi, P., Mouquet-Rivier, C., Amiot, M., Termote, C., and Pallet, D. (2022). Increasing pulse agrobiodiversity to improve food security and sustainable agriculture in sub-Saharan Africa. *Front Sustain Food Syst* 6:948808. doi: 10.3389/fsufs.2022.948808

Njoroge, S., and Zingore, S. (2022). Variability in Yield Response Strongly Affects Maize Productivity and Nutrient Requirements. *Growing Africa* 1:15–19. doi: 10.55693/ga12.EWJD1663

Nyamasoka-Magonziwa, B., Vanek, S., Carolan, M., Ojiem, J., and Fonte, S. (2021). Organic nutrient source allocation and use in smallholder farming communities: what are we missing? *Front Sustain Food Syst* 5:692981. doi: 10.3389/fsufs.2021.692981

Okelloh, W. O., Bett, H. K. A., and Sibiko, K. W. (2023). Development of improved groundnut varieties for dietary Upliftment among households in Homa Bay County, Kenya. *Asian J Agri Exten Econ Sociol* 40, 320–333. doi: 10.9734/ajaees/2022/v40i111715

Onyango, M. (2019). Comparative assessment of market-oriented patterns and utilization among rural grain legume smallholder farmers in Kenya. In: *Contributed paper in 6th African conference of agricultural economists, September 23rd–26th, 2019*, Abuja, Nigeria

Penafiel, D., Termote, C., and Van Damme, P. (2022). Traditional individual and environmental determinants of healthy eating in Vihiga County, Western Kenya. *Nutrients* 14:2791. doi: 10.3390/nu14142791

Perraud, E., Wang, J., Salomé, M., Huneau, J. F., Lapidus, N., and Mariotti, F. (2022). Plant and animal protein intakes largely explain the nutritional quality and health value of diets higher in plants: a path analysis in French adults. *Front. Nutr.* 9:924526. doi: 10.3389/fnut.2022.924526

Popoola, J. O., Aworunse, O. S., Ojuederie, O. B., Adewale, B. D., Ajani, O. C., Oyatomi, O. A., et al. (2022). The exploitation of orphan legumes for food, income, and nutrition security in sub-Saharan Africa. *Front. Plant Sci.* 13:782140. doi: 10.3389/fpls.2022.782140

Rothman-Ostrow, P., Gilbert, W., and Rushton, J. (2020). Tropical livestock units: re-evaluating a methodology. *Front Vet Sci* 7:556788. doi: 10.3389/fvets.2020.556788

Sharma, R., Sharma, S., Makroo, H., and Dar, B. (2022). Role of pulses to modulate the nutritive, bioactive and technological functionality of cereal-based extruded snacks: a review. *Int. J. Food Sci. Technol.* 57, 3882–3891. doi: 10.1111/ijfs.15186

Singh, N., Jain, P., Ujinwal, M., and Langyan, S. (2022). Escalate protein plates from legumes for sustainable human nutrition. *Front. Nutr.* 9:977986. doi: 10.3389/fnut.2022.977986

Singh, A. S., and Masuku, M. B. (2012). An insight statistical techniques and design in agricultural and applied research. *World J Agri Sci* 8, 568–584. doi: 10.5829/idosi.wjas.2012.8.6.1688

Snapp, S. S., Cox, C. M., and Peter, B. G. (2019). Multipurpose legumes for smallholders in sub-Saharan Africa: identification of promising 'scale out'options. *Glob. Food Sec.* 23, 22–32. doi: 10.1016/j.gfs.2019.03.002

Snapp, S., Rahmanian, M., and Batello, C. (2018). Pulse crops for sustainable farms in sub-Saharan Africa, Ed. T. Calles. Rome, FAO. doi: 10.18356/6795bfaf-en

Vaitla, B., Coates, J., Glaeser, L., Hillbruner, C., Biswal, P., and Maxwell, D. (2017). The measurement of household food security: correlation and latent variable analysis of alternative indicators in a large multi-country dataset. *Food Policy* 68, 193–205. doi: 10.1016/j.foodpol.2017.02.006

Vhurumuku, E. (2014) Food security indicators. In *Workshop on integrating nutrition and food security programming for emergency response: Food and agriculture organization (FAO)*. Kenya: Nairobi.

Wangila, A., Karuku Gachuiri, C., Muthomi, J., and Ojiem, J. (2021). Biomass yield and quality of fodder from selected varieties of lablab (*Lablab Purpureus* L) in Nandi south Sub-County of Kenya. *Online J Anim Feed Res* 11, 28–35. doi: 10.51227/ojafr.2021.6

WFP (2008). *Food consumption analysis: Calculation and the use of the food consumption score in food security analysis*. World Food Program, Vulnerability Analysis and Mapping Branch: Rome, Italy.

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., et al. (2019). Food in the Anthropocene: the EAT–lancet commission on healthy diets from sustainable food systems. *Lancet* 393, 447–492. doi: 10.1016/S0140-6736(18)31788-4

Wood, J. A. (2017). Evaluation of cooking time in pulses: a review. *Cereal Chem.* 94, 32–48. doi: 10.1094/CCHEM-05-16-0127-FI

Wudil, A., Usman, M., Rosak-Szyrocka, J., Pilař, L., and Boye, M. (2022). Reversing years for global food security: a review of the food security situation in sub-saharan africa (ssa). *Int. J. Environ. Res. Public Health* 19:14836. doi: 10.3390/ijerph192214836

Zhu, F., Du, B., and Xu, B. (2018). Anti-inflammatory effects of phytochemicals from fruits, vegetables, and food legumes: a review. *Crit. Rev. Food Sci. Nutr.* 58, 1260–1270. doi: 10.1080/10408398.2016.1251390