

Artículos

Food Security in Rural Sudan*

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Abstract:

The purpose of this paper is to examine the factors affecting food security for rural Sudanese households and to estimate price and income elasticities for Sudanese households based on their food security status. The results show that households living in northern and western rural regions are less likely to be food secure as compared to households living in eastern rural regions. Also, rural households are more likely to be food secure in the fall and winter seasons as compared to summer season. The results of price and income elasticities for secure and insecure households were almost similar. Income elasticities for both secure and insecure households show that cereals, milk & eggs, vegetables, staples, tea and coffee are necessities for rural households.

Keywords: Quadratic Almost Ideal Demand System, food security, rural household consumption, demographic factors.

Seguridad alimentaria en las zonas rurales de Sudán

Resumen:

El objetivo de este trabajo es examinar los factores que afectan a la seguridad alimentaria de los hogares rurales sudaneses y estimar las elasticidades de precios e ingresos de los hogares sudaneses en función de su situación de seguridad alimentaria. Los resultados muestran que los hogares que viven en las regiones rurales del norte y del oeste tienen menos probabilidades de tener seguridad alimentaria en comparación

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con los hogares que viven en las regiones rurales del este. Además, los hogares rurales tienen más probabilidades de tener seguridad alimentaria en las estaciones de otoño e invierno en comparación con la estación de verano. Los resultados de las elasticidades precio e ingreso de los hogares seguros e inseguros fueron casi similares. Las elasticidades de los ingresos de los hogares seguros e inseguros muestran que los cereales, la leche y los huevos, las hortalizas, los alimentos básicos, el té y el café son necesidades de los hogares rurales.

Palabras clave: sistema de demanda cuadrática casi ideal, seguridad alimentaria, consumo de los hogares rurales, factores demográficos.

Introduction

World Bank (WB) forecasts that by 2030 around half of the world's extreme poor population will be facing serious risks such as food insecurity (WB, 2020), which is a global concern in several studies (Davis & Geiger, 2017; Gundersen & Ziliak, 2018). In light of the developing world, millions of people are suffering from inadequate supply of food necessary for an active and healthy life. In Africa, food insecurity is a chronic problem and it is expected to prevail with the deteriorated climate change and constant population growth (Khan et al., 2014). Globally, the highest prevalence of malnourished people is found in sub-Saharan Africa [SSA], where the food insecurity problem is more common among households in rural areas (Shahraki et al., 2016; World Health Organization [WHO], 2018).

Regarding Sudan as a developing country located in SSA, the magnitude of food insecurity is widely spread among vulnerable groups in the country (FAO, 2012). Despite being one of the richest countries in SSA (Ibnouf, 2009), in terms of the diversity of the natural endowments, mainly the agricultural endowments, food insecurity is prevalent among Sudanese rural households. FAO (2020a) indicated that the growing economic distortions and crises have influenced food insecurity levels. Also, Sudan has been ranked as seventh in terms of worst food crises countries in 2019. Basically, the backbone of the Sudanese economy is the agricultural sector, which is the main source of livelihood for rural households. However, its contribution to the GDP drops from 25.4% in 2017 to 23.9% in 2018 (Central Bank of Sudan [CBS], 2019). A recent study (Rokhmatuloh et al., 2020) confirmed that food security is a critical issue in the agricultural sector that has not yet been resolved. The food table of the Sudanese population mostly contains sorghum and millet products, which are forms of primary food for most Sudanese citizens, especially for the residents of rural areas. The food supply of sorghum and its products in terms of kcal/capita/day dropped by 2.4% from 2014 to 2017 (FAO, 2020b).

Incompetent administration of the natural resources, civil wars, pasture and triable conflicts, and instability of agriculture policies have led millions of Sudan's population to suffer from food insecurity and chronic food poverty (Mahgoub, 2014; Almosharaf & Tian, 2014). Moreover, over the few last decades, a growing number of the Sudanese population, increasing in foreign refugees, climate change, economic crisis, and neglectable (negligent?) agriculture activities are the main challenges facing the national authority to secure food in rural and remote areas. Additionally, the urbanization of the agricultural lands and constant growth of total population generated a remarkable impact on the food security. Even though previous studies worldwide have explored and estimated the demand for calories by analyzing income elasticities and associated them with food security in developing countries (Dawson & Tiffin, 1998; Dawson, 2002; Halicioglu, 2012), to the authors' knowledge, no study has investigated the elasticity of the kilocalorie (kcal) demand of both secure and insecure households in Sudan. Also, no study has examined the demand for food and nutrients in any forms (calories, fat, protein, etc.) in Sudan. Thus, in this context, which focuses on rural areas, the objectives of the study are to address households' food security status and

the effect of socio-economic factors influencing food security status. Furthermore, the study aims to analyze the (kcal) system of secure and insecure households with respect to food prices, expenditure, and income elasticities.

Literature review

Much of the literature on food security emphasizes evolving and testing elements of food insecurity at the household level (S. Maxwell, 1996), and how a common household responds to food insecurity including food budget adjustments, reduced food intake, and dissimilarities in types of food served (Seligman et al., 2010). Food insecurity is a powerful form of economic and social disadvantage and leads to changes in household behaviors. Household food insecurity arises when an individual or households' experiences doubt about future food availability and access (Frongillo & Bernal, 2014). There are distinguishing issues that affect consumption and habit of food, which directly contribute to the challenges of households' experiences (Boyle & Holben, 2013). The deficiency of income is not considered the main cause for food insecurity (De Beer et al., 2020). Food behaviors, expenditure, and consumption patterns affect dietary diversity and are significant indicators of household food insecurity (Shariff & Khor, 2008). Regarding the impact of the demographic/socioeconomic factors (e.g., region, age, sex, education level, family size, and race) on the status of food security, the application of Binary Logistic Regression (BLR) as a tool for analyzing the context of food security is extensive in many studies, which have shown that food insecurity was prevalent and associated with sociodemographic factors (Felker-Kantor & Wood, 2012; Jackson et al., 2019; Kharisma & Abe, 2019). BLR is one of the types of regression analysis where the dependent variable is nominal variable, which can only take two values (Food secure & Food insecure). The explanatory variables may be continuous or discrete (Sarkar & Midi, 2010). Tumaini (2020) applied the BLR to address the influence of household assets on food access in Tanzania and indicated that household food accessibility improves as household heads' education and the number of household's members earning income increase. Kharisma and Abe (2019) employed the BLR method to identify the main factors that influence low-income urban households' food security status in Indonesia and found that female and unemployed households are more likely to experience food insecurity, while age and education status were insignificant factors. Berra (2020) used a multivariate logistic regression model to identify a link between household food access and undernutrition in children in Ethiopia. The study concludes that household's food insecurity is not correlated with acute malnutrition in children, but the incidence of households' food insecurity is very common and more noticeable among households with undernourished children. Moreover, a recent study examined the relationship between seasonal food insecurity, socioeconomic characteristics and factors of agricultural production among small-scale subsistence farmers in rural northern Honduras and confirmed that socioeconomic characteristics (e.g., wealth index, land ownership, sources of household income, presence of migrant member in the household) and factors of agricultural production influence seasonal food availability, accessibility, and utilization (Dodd et al., 2020).

Moreover, several researchers applied other forms of logistic regression (such as multinomial, ordinal, binary and probit models) to examine the determinants of households' food security. Kidane et al. (2005) used probit regression and found that fertilizer use and improvement in the educational levels of household's heads leads to a relatively greater probability of food security in Ethiopia. Using ordinal logistic regression approach, Akbar et al. (2020) explored the impact of socioeconomic and demographic factors on households' food insecurity in Pakistan. They found that educated mothers and employment of couples improve food security. In Nigeria, Iorlamen et al. (2013) showed that the average age, education, income, food expenditure and quantity of food consumed were significantly higher for food secure households than food insecure households. In addition, age, income, and household size were contributing positively to household food security. However, few studies in

developing African countries have measured the impact of demographic factors on the daily calories' intake levels of households by using econometric analysis. Abebaw et al. (2020), studied the quantitative impact of rural outmigration on indicators of household food security in Ethiopia. The study confirmed that, on average, rural outmigration has significantly improved the number of daily calories consumed per adult equivalent. Moreover, Stevano et al. (2020) indicated that socio-economic factors (e.g., age, gender, wealth, and food knowledge) is a critical dimension of food consumption in Ghana.

Contrary to ad hoc demand estimations, demand systems are derived from consumer demand theory. In addition, demand system estimation approaches (e.g., QUAIDS) allow researchers to explore how consumers vary the quantity of food they consume in relation to changes in prices and income, along with any preference variables such as demographics and seasonal factors that cause a shift in demand curve by providing theoretically consistent estimates of corresponding elasticities (Sisman, 2016). Empirical estimations should comply with the theoretical restrictions (i.e., adding up, symmetry, and homogeneity) in order to derive reliable inferences. The homogeneity property indicates the absence of money illusion, which refers to demand for a good does not change in the case of proportional increase in prices and income. The consumer demand theory is based on utility maximization, which requires symmetry condition to be satisfied (Okrent & Alston, 2011).

Some studies of demand systems use static methods, which do not conform to symmetry and homogeneity conditions resulting from consumer behavior theory (Muellbauer & Pashardes, 1992). Therefore, some demand studies worldwide (Banks et al., 1997) and in developing countries (Obayelu et al., 2009; Olorunfemi, 2013) confirmed the relevance of Quadratic Almost Ideal Demand System (QUAIDS) in modelling consumer preferences (Hoang, 2018; Kharisma et al., 2020). QUAIDS has a number of desirable features. The model extends demand systems by incorporating the quadratic expenditure term. Thus, the model can perform better for patterns of observed consumer behavior. Furthermore, QUAIDS allows types of goods to be at different expenditure levels such as luxuries at low-income levels and necessities at higher levels (Banks et al., 1997).

Price and income elasticities could help in the construction and formation of policies that act as incentives to the farmers, suggestion for consumption basket, and their implications on household food security (Mittal, 2010). In Vietnam, Bairagi et al. (2020) used the QUAIDS model to estimate a complete food demand system. The results showed that the expenditure elasticities of rural populations are positive and declining as income increases and noticed that cross-price elasticities are higher in urban areas as compared to rural areas. Likewise, Sowunmi et al. (2020) used QUAIDS model to address household food demand under economic distortion in Nigeria. The results show that the compensated own-price elasticities are negative and inelastic. Other studies examined the demand for various forms of nutrients, particularly the dietary caloric intake and confirm that income has significant effect on the demand for food and nutrients and the income elasticities of nutrients are relatively low (Abdulai & Aubert, 2004; Tian & Yu, 2013). In addition, Lokuge et al. (2019) argued that the changes in price and income have an impact on the dietary caloric intake of households. Conversely, a study performed by Dawson (1997), in developing countries aimed to analyze demand elasticities of calories. The findings showed that caloric intake is significantly affected not only by income distribution and per capita income, but it is also determined by income growth, food support, urbanization, and social factors.

Data and empirical models

The study is conducted in the Eastern River Nile locality of Sudan. The study area forms a part of Northeast of Khartoum state, Sudan. Its municipality is located to 15 km to the east of Khartoum city centre, between latitudes of 15° 16' and 15° 36' N and longitudes of 32° 37' and 33° 03' E (figure 1). It occupies an area of 8188 km², which is

estimated as a third of Khartoum State's area. It has a total population of 1120, 753 persons in 2020 (SCBS, 2021). The weather is rainy in the fall, cold and dry in the winter. The average rainfall in the locality ranges from 100 to 200 mm in the north-eastern areas and from 200 to 300 mm in the north western areas. The temperature in summer ranges from 25 to 40 °C from April to June, and from 20 to 35°C in the months of July to October. In winter, the temperature declines gradually from 25°C to 15°C between November and March. The agricultural activity is the major source of livelihood for most of the people who are cultivating vegetables, field crops and fodders all year around.

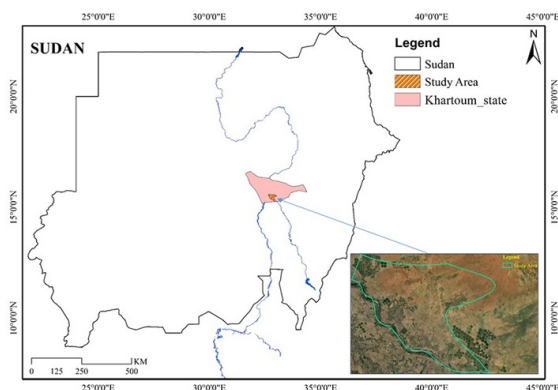


FIGURE 1

MAP OF THE EASTERN NILE LOCALITY IN KHARTOUM, SUDAN
SOURCE: ARCGIS (10.5) SOFTWARE

The area was selected as the study area because most of the residents originated from conflict and civil wars regions in Sudan, such as Jebel Marr and south Kordofan (in western Sudan), Blue Nile (in south east Sudan) and originated from the drought region in north Sudan. The study was conducted in households across different locations in the region. Structured and unstructured interviews were administered to household heads. Unstructured interview were performed with the village leaders asking for the general information of the villages and history information by using the guideline for structured questionnaires. Structured questionnaires were distributed among the household's heads for collecting information about various common food consumed per week, sociodemographic information, total household expenditures, and household's income level covering the balance year (2017-2018) during three dominant seasons (summer, winter and fall). The study applied the multi-stratified sampling technique through comprehensive interviews, the study area was divided into four strata (i.e., north, south, east, and west strata), from each strata 250 rural households were selected randomly with a targeted sample size of 1000 rural households.

The four pillars of the food security dimension that are widely used and accepted are availability, access, utilization, and stability (Dedehouanou & McPeak, 2018; Upton et al., 2016; Mughal & Fontan Sers, 2020). Our study focuses on food accessibility by collecting data on food expenditure to measure the per capita food expenditure and food utilization by different types of food groups consumed by households. The study analyzed seven groups of calories: cereals, meat and chicken, milk and eggs, vegetables, staples group, and caffeine calories group. (only 6 are mentioned!)

Food security status

The Average Dietary Energy Requirement (ADER) per adult equivalent per week in kcal is the standard measured by FAO (year). It is recognized as one of the most useful statistics for measuring food security as well as others familiar food security dimensions (availability, access, stability and utilization). Numerous studies (Akbar et al., 2020; Devereux, 2006; Mishra & Ray, 2009; Suryanarayana, 2001) have identified food insecurity status of each household on the basis of per adult capita daily consumption of calories by household. Food security based on FAO (2012) is defined by obtaining 2300 kcal per adult per day to satisfy the food security status.

In order to identify households' food security status and to determine the effect of sociodemographic factors that influence food security status, the data were analyzed using descriptive statistics, food security index estimation, and logistic regression analysis. Food security index was estimated using a caloric intake method of FAO (2012) to classify the households into food secure and food insecure households. The familiar approach of food security measurement, which was identified by D. Maxwell (1996) and has been largely applied in most food security studies, is to undertake a 24-hour recall of food consumption for individual members of a household and analyze each kind of food consumed for calorie amount. The study follows Devereux (2006), for calculating food security status of each household, which is determined on the basis of adult per capita daily consumption of calories by the household, and the formula is given as:

$$(1) CI_i = CA_i - CN_i$$

Where CI is calorie intake, CA is caloric availabilities and CN_i is the caloric needs for the *i*th household. When $CI_i \geq 0$, it indicates that the household is food secure. Conversely, when $CI_i < 0$ indicates that the household is food insecure. By proposing a linear function derived by Feleke et al. (2005), in developing countries, the food security equation can be expressed as:

$$(2) CI_i = \sum_{j=1}^{k=10} \alpha_j X_{ij} + \varepsilon_i$$

The household is detected to be secured ($H_i = 1$), which is assumed to have $CI_i \geq 0$ and the household is detected to be insecure ($H_i = 0$), which assumed to have $CI_i < 0$. Since the dependent variable H_i is a discrete variable, hence the food security equation can be identified as a qualitative model where ϕ_i is the probability of food security, which can be written as:

$$(3) \phi_i = Prob(H_i = 1) = Prob\left(\sum_{j=1}^{k=10} \alpha_j X_{ij} + \varepsilon_i < 0\right)$$

Further, the logistic regression model of food security is computed obviously for identifying the factors affecting the capability of the household to secure available food provisions, which is specified by Demaris (1992), as follows:

$$(4) Ln\left(\frac{\phi_i}{1 - \phi_i}\right) = \alpha_0 + \sum_{j=1}^{k=10} \alpha_j X_{ij} + \varepsilon_i$$

\emptyset_i is the conditional probability of food security; ; α_j 's are parameters to be estimated; whereas X_{ij} denotes to the independents variables which are defined in table 1.

TABLE 1
DESCRIPTION OF THE LOGISTIC REGRESSION INDEPENDENT VARIABLES

Variables	Description and (labels)
X1	Household head's monthly income in Sudanese pounds (HH-income).
X2	Age of the household head in year (Age-HH).
3X	Household's size (Number of family members).
X4	Number of males in the household.
X5	Gender of the household head.
X6	Marital status of the household head.
X7	Location of the household originating from northern region (Northern region).
X8	Location of the household originating from southern region (Southern region).
X9	Location of the household originating from western region (Western region).
X10	Local name of an informal education in Sudan (<i>Khalwa</i>).
X11	Household head has reached primary education level (primary school).
X12	Household head has reached intermediate education level (intermediate school).
X13	Household head has reached high school education (high school).
X14	Household head has obtained at least bachelor's degree.
X15	Farming is the only occupation practised by the household head (Farmer).
X16	Farming and livestock rearing are the main occupation of the household head (Farmer and shepherd).
X17	Household is headed by woman and housewife is the main occupation of the household head (housewife).
X18	The main occupation of the household head is permanent labour (Labour)
X19	The main occupation of the household head is rearing the farm livestock around the village (shepherd).
X20	The main occupation of the household head is teaching (teacher).
X21	The main occupation of the household head is trade with basic needs commodities, specifically the food commodities (trader).
X22*	Amount of food consumed by the household during winter season in kg/ week.
X23*	Amount of food consumed by the household during fall season in kg / week.

Source: own source

* The amount of food consumed is converted later in calories per week per household. The quantity of each consumed food was converted to food energy by using the general factor that expresses the amount of available energy per unit of weight.

The dependent variable is food security status, which takes the value of one and represents food secure household and zero representing food insecure household. The results of logistic regression in equation (5) according to (DeMaris, 1992; Garson, 2016), can be displayed in forms of conditional probabilities instead of log odds by calculating the probability of food security as:

$$(5) \quad \emptyset_i = \frac{e^{\left(\sum_{j=1}^{k=10} \alpha_j X_{ij}\right)}}{1 + e^{\left(\sum_{j=1}^{k=10} \alpha_j X_{ij}\right)}}$$

Moreover, the study tries to calculate the marginal effects (ME) of the food security factors, which are often reported with the logistic regression method to compute the incremental risk associated with each factor (Norton et al., 2019). When the conditional probabilities are estimated for the individual household, the ME of the continuous individual variables on household food security can be estimated as:

$$(6) \frac{\partial \phi_i}{\partial X_{ij}} = \phi_i(1 - \phi_i) \alpha_j$$

The ME for dummy variables can be estimated by taking differences of the mean probabilities, which is estimated for the particular discrete variables as follows:

$$(7) ME = F(\alpha \bar{X} | \bar{X} = 1) - F(\alpha \bar{X} | \bar{X} = 0)$$

Whereas $F(\cdot)$ is a cumulative distribution function that plots the values of (0,1) interval. Feleke et al. (2005), argued that the given definition of the marginal effect of dummy variable is complex since it avoids the problem of setting dummy variables to means.

Although caloric intake (kcal) may not cover the wider knowledge of food security, it may be measured as a principal indicator of food insecurity at household level (Akbar et al., 2020; Beegle et al., 2012). Accordingly, the study tries to analyse calorie elasticities based on the empirical model of QUAIDS, which is essentially an extended form of AIDS model. The model is quadratic in per capita expenditure under the assumption that there is a non-linear relationship between income and expenditure, i.e., budget share Engel curve is assumed to be non-linear such that commodities can be a luxury for the poor households but a necessity for richer households (Deaton & Muellbauer, 1980).

According to Banks et al. (1997), the QUAIDS is basically derived from the indirect utility function (U) of a consumer given by:

$$(8) \ln V = \left\{ \left[\frac{\ln m - \ln a(p)}{b(p)} \right]^{-1} + \lambda(p) \right\}^{-1}$$

Whereas $[\ln m - \ln a(p)]$, is indirect utility function, m is the total food expenditures of the household, p is a vector of the nominal prices, whereas $\ln a(p)$ is a price index that takes the translog form as:

$$(9) \ln a(p) = \alpha_0 + \sum_{i=1}^n \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n \gamma_{ij} \ln p_i \ln p_j$$

Likewise, $b(p)$ is denoted as the simple Cobb-Douglas price aggregator of the price vector (p) defined in Deaton and Muellbauer's (1980), AIDS model as below:

$$(10) \quad b(p) = \prod_i^n p_i^{\beta_i}$$

Furthermore, $\lambda(p)$ is the price aggregator function, which is homogenous of degree zero in prices, then $\lambda(p)$ form as:

$$(11) \quad \lambda(p) = \sum_{i=1}^n \lambda_i \ln p_i,$$

$$(12) \quad \sum_{i=1}^n \lambda_i = 0$$

Where $i=1, \dots, k$, represents the numbers of commodities entering the demand model. Equations (10-12) contain the QUAIDS's model specification. The parameters α_i , γ_{ij} , β_i , and λ_i are determined by the utility that a consumer receives from consuming a good. By applying the Roy's identity equality to the indirect utility function (equation 8), QUAIDS model of the budget share of food group $I(w_i)$ is written as:

$$(13) \quad w_i = \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln p_j + \beta_i \ln \left(\frac{m}{a(p)} \right) + \frac{\lambda_i}{b(p)} \left\{ \ln \left[\frac{m}{b(p)} \right] \right\}^2 + \varepsilon_i$$

The study incorporates demographic variables (z_d) scaling into QUAIDS (Ray, 1983) following (Capacci & Mazzocchi, 2011; Law et al., 2020) for monitoring the variation of preference and heterogeneity across households. Therefore, the equation (13) is modified as below:

$$(14) \quad w_i = (\alpha_i + \sum_{d=1}^D \alpha_{id} z_d) + \sum_{j=1}^n \gamma_{ij} \ln p_j + (\beta_i + \sum_{d=1}^D \beta_{id} z_d) \ln \left[\frac{m}{a(p)} \right] + (\lambda_i + \sum_{d=1}^D \lambda_{id}) \frac{1}{b(p)} \left\{ \ln \left[\frac{m}{a(p)} \right] \right\}^2 + \varepsilon_i$$

The estimation of QUIADS requires the following parametric restrictions:

Adding up:

$$(15) \quad \sum_{i=1}^n \alpha_i = 1, \quad \prod_i^n p_i^{\beta_i} = 0, \quad \sum_{i=1}^n \lambda_i = 0,$$

Homogeneity:

$$(16) \sum_{i=1}^n \gamma_{ij} = 0, \text{ and}$$

Slutsky symmetry:

$$(17) \sum_{j=1}^n \gamma_{ij} = 0, \gamma_{ij} = \gamma_{ji} .$$

The formula for elasticities in the QUAIDS is specified by Banks et al. (1997). The price and expenditure elasticities are obtained by partially differentiating equation (14) with respect to $\ln m$ and $\ln p_j$.

$$(18) \mu_i = \frac{\partial \omega_i}{\partial \ln m} = \beta_i + \frac{2\lambda_i}{b(p)} \left\{ \ln \left(\frac{m}{a(p)} \right) \right\},$$

$$(19) \mu_i = \frac{\partial \omega_i}{\partial \ln p_j} = \gamma_{ij} - \mu_i \left(\alpha_j + \sum_{j=1}^n \gamma_{ij} \ln p_j \right) + \frac{\lambda_i \beta_j}{b(p)} \left\{ \ln \left(\frac{m}{a(p)} \right) \right\}$$

Furthermore, the expenditure elasticity is estimated as:

$$(20) E_i = \frac{\mu_i}{w_i} + 1$$

Whereas the uncompensated (Marshallian) price elasticity is estimated as:

$$(21) E_{ij}^u = \frac{\mu_{ij}}{w_i} - \delta_{ij}, \text{ where } \delta_{ij} \text{ is Kronecker delta which} = 1 \text{ when } i=j \text{ and zero otherwise.}$$

The above elasticities are important because they show the responsiveness of quantity demanded to changes in product's own price, alternative/substitute products' prices, and income changes. The elasticities are measured in the context of this paper is to reveal how quantity demanded is affected by changes in income and commodities prices for both secure and insecure households.

By using the Slutsky equation, the compensated (Hicksian) price elasticities are computed as:

$$(22) E_{ij}^c = E_{ij}^u + E_e w_i$$

In this study, the elasticity of demand calories is estimated instead of the food consumed by the households for satisfying the rural household food security measurement.

Results and discussion

Main findings highlight that the percentage of food secure households is 48% and that of food insecure households is 52%. Table 2 reflects that the mean age of the insecure and secure household's head is 54 and 45 years, respectively. Food insecure households, when compared to food secure households, have a greater mean number of individuals living in the same home: 9 persons (SD±3.07) set against 5 persons (SD±2.58). One explanation of this result is that the increase of food insecurity is linked with high family size. This result, confirm the statement that food accessibility worsens as household size increased (Tumaini, 2020). The food expenditure among secure households is higher (451.763 ± 253.59) as compared to the insecure households (376.985 ± 264.455) and absolutely the total caloric intake of secure households is more than insecure households and secure households consume more calories of the all-selected food groups (table 2).

TABLE 2
DESCRIPTIVE STATISTICS FOR DEMOGRAPHIC VARIABLES AND FOOD CONSUMPTION

Variables	Food Insecure (N=1516)		Food Secure (N=1426)	
	Mean	Std. Dev.	Mean	Std. Dev.
HH-Age	54	16.259	45	15.757
HH-Size	9	3.070	5	2.582
Gender (Male)	0.652	0.476	0.630	0.483
Marital Status (Married)	0.891	0.312	0.813	0.390
Total Expenditure (Sudanese Pound)	376.985	264.455	451.763	253.597
Total Calories	11583.830	3113.654	23922.030	9810.226
Cereals Cal	7012.199	2450.207	14814.300	7529.692
Meat & Chicken Cal	1662.140	838.831	3391.125	2330.977
Milk & Eggs Cal	360.718	188.876	685.830	1353.735
Vegetables Cal	294.068	174.776	549.415	281.838
Staples Cal	2252.255	1343.063	4477.317	2908.278
Tea & Coffee Cal	2.451	2.803	4.041	5.289

Source: own source

Note: All listed calories are in kilo calorie per household per week.

The results of the estimated logit model are shown in table 3. The result of Hosmer and Lemeshow test shows that the model is a good fit. The post-estimation test results suggest that the model is 80% correctly classified.

The results show that for every Sudanese pound increase in household income, the household is more likely to be food secure. Rural households that have at least a bachelor's degree are more likely to be food secure as compared to illiterate households. The probability of bachelor's degree-educated household to be food secured is 59% higher than illiterate households. In addition, households holding intermediate school and high school certificates, respectively, are more likely to be food secure as compared to illiterate households. Also, for an additional member in the household, the probability of household to be food secure decreases by 8%. Furthermore, female headed households are less likely to be food secure as compared to male headed households. Households living in the western and northern rural areas are less likely to be food secure compared to households living in the eastern rural region. Moreover, households in the winter and fall seasons are more likely to be food secure as compared to the summer season.

TABLE 3
LOGISTIC REGRESSION AND MARGINAL EFFECT ESTIMATIONS FOR FOOD SECURITY IN SUDAN (2017/2018)

Variables	LR	ME	Variables	LR	ME
HH-Income	0.0043*** (0.00)	0.0006*** (0.00)	Bachelor's	4.3679*** (0.72)	0.5943*** (0.09)
Age-HH	-0.0032 (0.01)	-0.0004 (0.00)	Farmer	0.0300 (0.63)	0.0040 (0.08)
HH_Size	-0.6596*** (0.04)	-0.0898*** (0.00)	Farmer& Shepperd	-1.0704 (1.02)	-0.1419 (0.13)
Male numbers	-0.0283 (0.05)	-0.0038 (0.01)	Housewife	-0.7660 (0.69)	-0.1021 (0.09)
Gender	-0.8342*** (0.26)	-0.1135*** (0.03)	Labour	-0.6643 (0.80)	-0.0886 (0.11)
Married	0.1213 (0.20)	0.0165 (0.03)	Shepherd	-0.7984 (0.78)	-0.1063 (0.10)
Northern region	-1.0483*** (0.20)	-0.1507*** (0.03)	Teacher	-1.6313** (0.81)	-0.2124** (0.10)
Southern region	-0.2379 (0.18)	-0.0337 (0.03)	Trader	0.1165 (0.71)	0.0154 (0.09)
Western region	-1.2395*** (0.28)	-0.1780*** (0.04)	Winter S	0.9525*** (0.11)	0.1308*** (0.02)
<i>Khalwa</i>	-1.0669 (0.94)	-0.1452 (0.13)	Fall S	0.4661*** (0.10)	0.0643*** (0.01)
Primary school	-0.2077 (0.35)	-0.0283 (0.05)	Constant	3.5389*** (0.74)	
Intermediate school	0.6861* (0.41)	0.0934* (0.05)	Observations	2925	2925
High school	0.8696* (0.52)	0.1183* (0.07)	- Hosmer- lemeshow chi2(8) =10.51 - Prob> X2 = 0.2308.		

Source: own source

Notes: Abbreviation, LR: Logistic regression and M.E: marginal effects.

Standard errors in parentheses * p < 0.10, ** p < 0.05, *** p < 0.01.

There are certain commodities that are considered essential commodities for rural residents in Sudan. Particularly, cereals, meat and chicken, milk and eggs, vegetables, staples, tea and coffee are considered important

commodities for rural Sudanese residents. In order to examine the responsiveness of quantity demanded for those essential commodities to price and income changes, we estimated demand elasticities for food secure and food insecure households as shown in tables 4 and 5, respectively.

TABLE 4
MARSHALLIAN PRICE ELASTICITIES AND EXPENDITURE ELASTICITY ESTIMATES FOR
THE QUAIDS MODEL FOR FOOD CONSUMPTION IN RURAL SUDAN (FOOD INSECURE)

Variables	Cereals	Meat & Chicken	Milk & Eggs	Vegetables	Staples	Caffeine Intake	Expenditure Elasticities
Cereals	-0,0741 0,0142	-0,0960 0,0202	-0,0429 0,0079	-0,1271 0,0071	-0,0098 0,0037	-0,0555 0,0032	0,4054 0,0156
Meat & Chicken	-0,2107 0,0049	-0,8858 0,0093	-0,1183 0,0036	-0,0735 0,0031	-0,0398 0,0016	-0,0139 0,0014	1,3419 0,0065
Milk & Eggs	-0,1182 0,0169	-0,3730 0,0282	-0,1062 0,0279	-0,0683 0,0175	0,0456 0,0108	0,0338 0,0082	0,5862 0,0189
Vegetables	-0,3717 0,0190	-0,1597 0,0314	-0,0851 0,0217	-0,0427 0,0254	0,0104 0,0118	0,0947 0,0090	0,5540 0,0216
Staples	-0,0167 0,0203	-0,0724 0,0319	0,1446 0,0280	0,0436 0,0248	-0,3839 0,0277	0,0182 0,0122	0,2666 0,0206
Caffeine Intake	-1,3040 0,0687	-0,5529 0,1105	0,3160 0,0835	0,7398 0,0738	0,0481 0,0476	0,0088 0,0490	0,7443 0,0760

Source: own source

Note: Numbers in parentheses are standard errors. Elasticities in bold are statistically significant at 5% level or better.

TABLE 5
MARSHALLIAN PRICE ELASTICITIES AND EXPENDITURE ELASTICITY ESTIMATES FOR
THE QUAIDS MODEL FOR FOOD CONSUMPTION IN RURAL SUDAN (FOOD SECURE)

Variables	Cereals	Meat&Chicken	Milk&Eggs	Vegetables	Staples	Caffeine Intake	Expenditure Elasticities
Cereals	-0,0644 0,0144	-0,0413 0,0198	-0,0444 0,0080	-0,1241 0,0072	-0,0108 0,0037	-0,0572 0,0032	0,3421 0,0171
Meat&Chicken	-0,2122 0,0048	-0,9490 0,0086	-0,1186 0,0035	-0,0772 0,0031	-0,0394 0,0015	-0,0132 0,0013	1,4097 0,0066
Milk&Eggs	-0,1036 0,0181	-0,2189 0,0289	-0,0450 0,0295	-0,0588 0,0184	0,0507 0,0114	0,0356 0,0087	0,3400 0,0213
Vegetables	-0,3348 0,0186	0,0083 0,0297	-0,0716 0,0212	-0,0614 0,0245	0,0131 0,0115	0,0919 0,0088	0,3544 0,0225
Staples	-0,0413 0,0230	-0,0843 0,0348	0,1534 0,0316	0,0471 0,0277	-0,3096 0,0312	0,0179 0,0138	0,2168 0,0250
Caffeine Intake	-1,5499 0,0852	-0,5121 0,1336	0,4054 0,1028	0,9309 0,0901	0,0665 0,0586	0,2422 0,0601	0,4169 0,1031

Source: own source

Note: Numbers in paranthesis are standard errors. Elasticities in bold are statistically significant at 5% level or better.

The income/expenditure elasticity shows that cereals, milk & eggs, vegetables, staples, and caffeine intake are all necessities for rural Sudanese households whether food secure or food insecure. Also, these food items are income inelastic, indicating that a one-percent increase in rural Sudanese household income increases the demand for those food items by less than one percent. Conversely, income elasticity shows that meat and chicken are luxury food items for both food secure and food insecure households.

The own-price elasticities for both food secure and food insecure household are inelastic, except caffeine intake, showing that changes in price of cereals, meat & chicken, milk & eggs, vegetables, and staples slightly affect quantity demanded of these food items. Moreover, most cross-price elasticities are negative, indicating that the food items under investigation are complements for Sudanese rural households.

Conclusion

Food security and nourishment in Sudan continues to face significant challenges due to instable and sharp increases in food prices, climate change, civil wars, agriculture downturn, economic shocks, and political crisis despite the natural resource diversifications in the country. As a result, this paper examines factors affecting food security for rural Sudanese households based on a caloric intake approach. The results show that increases in rural household income increase the likelihood of food security while any increase in household members decreases the likelihood of food security. Also, households living in western and northern rural regions are less likely to be food secure as compared to households living in eastern rural regions. Also, rural households are more likely to be food secure during winter and fall seasons as compared to the summer season. Also, households holding intermediate school certificates, high school certificates, and bachelor's degrees are more likely to be food secure as compared to illiterate households. The paper also estimated price and income elasticities for both food secure households and food insecure households and the results were almost similar between the two groups. The results show that cereals, milk & eggs, vegetables, staples, and caffeine intake are considered necessities for rural Sudanese households. Conversely, chicken and meat are luxury items for Sudanese rural households. The own-price elasticities are negative and inelastic, indicating the changes in prices of cereals, milk & eggs, meat & changes, vegetables, staples, and coffee & tea slightly affect quantity demanded of these food items. Furthermore, the cross-price elasticities indicated that these food items are mostly complements for Sudanese rural households.

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Notes

- * Research article.

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