Determinants of Food Security in Gezira Scheme of Sudan

Omima A. Mirghani[1], Abdelateif H. Ibrahim[2], Abdelaziz A. Hashim[3] and Awad Elkarim S. O. Khalifa[4]

[1]Department of Agric-Economics, Faculty of Agriculture, Omdurman Islamic University, Sudan
[2]Department of Agric-Economics, Faculty of Agriculture, University of Khartoum, Sudan
[3]Agricultural Economics and Policy Research Centre, Khartoum North, Shambat, Sudan
[4]Institute of Gum Arabic Research and Desertification Studies, University of Kordofan, Sudan

Abstract- In spite of the vast efforts that have been made by government and NGOs to sustain food security in Sudan, still 4.5 million people of Sudanese are food insecure. Many factors are accountable for this, including: limited access to food, due to low productivity of crops and severely increase of food prices. This tough situation forced farm households to adopt different strategies to cope with their food gaps which is reported between (51-91%) of the total requirements. This paper aims at determining the factors that influence food security among farm households in rural Sudan taking Gizera and Managil localities as case in point. It tries to discuss the guidelines, tools and frameworks for evaluating and measuring of household food security in the area. The data used in this study were collected in 2015, using a structured questionnaire. It surveyed 200 farm households in 12 villages distributed in targeted localities. For accuracy and precision scheme area was divided into 2 geographical areas – 5 groups and 10 blocks. Afterward, 20 households were randomly sampled in each of the 10 blocks, using a multi - stage stratified random sampling technique. Key resource persons were also interviewed using focus group discussion. Descriptive statistical analysis and logit model were applied to analyze the data. Moreover, the study used the daily amount of cereals requirements recommended by FAO and WHO with average food needs at about 400 grams of cereal crops per person per day couple with average dietary energy consumption derived from other food items (Kcal/person/day) as indicators to characterize the household status to food secure and insecure. The results of the descriptive statistics show that 65% of sampled households did not have enough food to secure their needs, particularly during the off-season, whereas 63% of households reported insufficient income to buy food.The results also revealed that the problem of seasonality and inaccessibility due to higher food prices have a greater impact on households food security and consequently their standard living conditions. The results obtained from logit model demonstrated that the current situation of food security of household is influenced significantly by household size, labor hired-out, miscellaneous income and cultivation of cotton and groundnuts. The study suggests that the farmers should be adequately motivated with needed technology so as to enhance their agricultural production. Furthermore, diversification of income sources is highly required as this will go a long way in improving their livelihood. This could be possible through encouraging income generating activities especially in the areas vulnerable to food insecurity.

Index Terms- Food security, Food prices, Income, Household, Access, Logit model

I. INTRODUCTION

1.1 Background

With total land area of about 1,886,068 km^2 Sudan is ranked as the third largest country and one of the most diversified countries in Africa. It lies wholly between longitudes 4°, 24° north, and latitudes 22° and 38° and is bisected by the Nile River and its tributaries, where most of the population is concentrated. Empirical evidence suggests that economic development in Sudan is possible only through investment in the agricultural sector due to the availability of resources in terms of water, arable land and livestock (Moi, 2012). Although the contribution of agricultural sector to economic development has declined steadily during the past years due to the focus devoted to the oil sector, its remains important to the majority of the Sudanese population, especially those who live in remote areas. More than 80% of farm households engage in agriculture and 70% obtain their livelihoods from agricultural earnings (Sifsia, 2011). The diversity of geography is also reflected on its demographic composition; and as a result, the country is multi-cultural, multi-ethnic, multi-lingual and multi-religious (IPRSR, 2003). A way from the River, pastorals and shifting are widely practiced where large movements of people have occurred in many regions due to civil strife in the west and east, and drought and environmental degradation in the north. These factors have caused reduction of agricultural production, widespread livestock loss, increasing seasonal migration of men seeking work in urban and irrigated area of the country (IFAD, 2004). Moreover, the persistent food crises have left a significant proportion of the Sudanese population suffering from food insecurity. Recent literature has shown that the prevalence of undernourishment was 31 percent and 34 percent for urban and rural populations, respectively. More precisely, one in three Sudanese severely suffered undernourishment (ABDELGADIR, 2012). Current study confirmed that 4.4 million people in the Sudan are food insecure, due to civil conflicts and reduced access to food as a result of gradual depletion of household food stocks (IPC, 2016).

At present, the gradual rising of food prices is creating a great challenge to the food security of Sudan. Recognizing that the main problem of food security in Sudan is lack of access rather than an aggregate shortage of supplies, food security may be analyzed for units at different conceptual levels: regions, countries, households and individuals. Much analysis of the topic has focused on the macro levels. Even though food security for individuals is often the main focus of attention, food security is however a measure of a household condition, not that of each individual in the household. Therefore, not all individuals in a food insecure or hungry household are food insecure. This issue is especially important for young children who are often shielded from even the most severe forms of food insecurity and hunger. It is, therefore, important to understand how far agricultural resources used to reduce vulnerability of food insecurity? And what are the socioeconomic characteristics of the food insecure people? Does the greater access to non –farm activities influence the food security status of farm households? How can cash crops stimulate agricultural development?

1.2 Statement of the Problem

Throughout history, people have assumed that producing their own food was the basis of their survival and that self-reliance in food production is the basis of genuine food security for them. There is nowadays a great deal of concern amongst development economists as related to the appropriate development strategy that Less Developing Countries (LDCs) should follow in order to solve their food security problem. Whether these countries should adopt food crop strategy or cash crop strategy would depend in the first place on which of the two strategies will achieve food security. Early definitions of food security focused on aggregate food supplies at national and global levels, and analysts advocated production self-sufficiency as a strategy for nations to achieve food security. The 1974 World Food Conference defined food security as: "availability at all times of adequate world supplies of basic food-stuffs" (United Nations 1975). Just 12 years after the World Food Conference, however, the World Bank proposed a definition of food security which remains current today, that broadened the emphasis from food availability to include access to food, and narrowed the focus from the global and national to households and individuals: "access by all people at all times to enough food for an active, healthy life" (World Bank, 1986). Since the 1980s, it has been recognized that the achievement of food security requires paying attention to both supply-side and demand-side variables.

In recent times however, there has been a considerable shift on the emphasis on food security from the national to the household level. At the household level food security refers to the ability of the household to secure food either from its own production or through purchases of local or imported commodities, adequate food for meeting the dietary needs of all members of the household. Producing additional food locally is a major challenge when population and incomes are rising, and natural resources degrading.
Therefore, this paper intends to estimate the extent of food security status of the farm households taking the Gizera scheme as case in point. Specifically, this paper tries to identify the factors that influence the farm household's food security status in the study area.

II. METHODOLOGY

2.1 Data collection source

The analysis for this study is mainly based on primary data which include information collected through field survey conducted by the researcher using structured questionnaire.

2.2 Sampling procedure

The surveyed sample consists of 200 farm households, which were selected through Multi-stage stratified random sampling procedure. The Gezira scheme is divided into groups, which are further sub-divided into blocks, covering the two areas, Gezira Main and Managil Extension. Randomly three groups at (north, center and south) and two groups at (north and center) were selected from Gezira Main and Managil Extension respectively. Then two blocks were randomly selected from each group (10 blocks) and from each block 20 households were randomly selected. So the total sample size was 200 households. The data collected were analyzed using descriptive statistics and logistic regression.

2.3 The study area

The Gezira Scheme is located between the Blue and White Nile rivers south of Khartoum at approximately 13^0 and 15^0 North latitude. It covers a net cultivable area of little less than one million hectares (about 2.1 million feddan). The Scheme consists of two main parts: Gezira main with an area of 1.1 million feddan and Managil Extension of 1 million feddan (Adam, 1996). The Scheme is irrigated principally by gravity irrigation from the Sennar Dam on the Blue Nile. Gezira Scheme has a gentle slop to the north and west of the Blue Nile, it is suitable for gravity irrigation. The irrigation system of the scheme is basically a gravity flow system where water is derived from Sennar Dam into the two main canals which supply main Gezira and Managil extension. These canals ramify into laterals and sub-laterals (Adam, 1996).

Gezira scheme is the largest irrigated scheme under one management in the world. Estimates of the total potential cultivable area under irrigation in Sudan within the Nile basin vary, but it is probably between four and five million feddan. Hence the Gezira Scheme represents about a quarter of all irrigation area in Sudan and half the area of irrigation schemes drawing water from the Nile system. It uses about 35% of Sudan's current allocation of Nile water (World Bank Report 2000). One of the main objectives of the scheme since its existence was the production of long staple cotton. However, the prevailing farming systems in the scheme aim to produce food and high value export crops for self-sufficiency and for export, respectively. One of the scheme main objectives is to promote social development of the tenant as well as people residing in the scheme area through better schooling, medical care, and creation of job opportunities and the sense of security through better settlement (Ahmed, 1997).

The main crops produced in the Gezira scheme are cotton, groundnut, wheat and sorghum (dura), in addition to minor crops such as vegetables. During the period from 2004 to 2009, of the total production in the country, the scheme contributed 31 percent of cotton, 24 percent of wheat, 20 percent of groundnut and 24 percent of sorghum (table 2.1). The main vegetable crops produced in the scheme are onion and tomato which account for 60 percent of the total area under vegetables and are mainly consumed locally (Mirghani *et al*, 2002). Moreover, there is a considerable amount of livestock in the scheme.

2.4 Analytical tool - logistic regression

In analysis where the outcome variable is binary, linear regression models cannot be applied. This is because in linear regression models, there is an assumption of linear relationship between variables, when the outcome variable is dichotomous, this assumption is violated (Field, 2005) and the regression equation is expressed in terms of the probability of Y occurring. That is, the probability that a household belongs in a certain category. The logistic model was adopted because of its simplicity in numerical estimation (Hill *et al*, 2001). In a logistic model, the resulting value from the model is a probability value that ranges between 0 and 1. Therefore, a value closed to 0 would imply that food security is very unlikely to occur and a value closed to 1 implies that food security is very likely to occur.

The binary logistic regression was used to determine the effects of some socioeconomic characteristics of the households on their food security status. The parameter of the logistic regression model was estimated with the Maximum Likelihood Estimation (MLE) technique. A binary response function (food secure and food insecure) was specified and estimated by the logistic procedure. The binary logistic specification is suited to models where the dependent variable is dichotomous, which in this case are the households who are food secure and those who are food insecure.

Food security status was measured using a bid value of one or zero, where one represents food secure and zero represents food insecure.

Once the demand for both home-produced and market-purchased goods was determined, the amount of calories (Ci) defined as calorie availability, and (yi) is consumption needs in calories, household food security is determined by the difference between calorie availabilities and needs:

$C_i^* = C_i - y_i$ ……..... (6.2)

Where Ci is the calorie availability and Y is the consumption needs for th i^{th}household, $C_i^* > 0$ corresponds to the consumption demand exceeding the household calorie needs while $C_i^* < 0$ corresponds to the consumption demand failing to meet the household calorie needs.

The logistic regression then provides a model of observing the probability of a household becoming food secure or food insecure. The logistic model is specified explicitly as:

Pi = prob (Yi = 1) = prob ($\sum \beta_j X_{ij} + \varepsilon_i > 0$) ……..…… (6.3)

Based on equation (6.2) a logistic regression model of food security as proposed by Demaris, (1992) and Afari, (2006) can be specified as follow:

$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{j=1}^{k=10} \beta_j X_{ij} + \varepsilon_i$ .....(6.4)

Where P_i the probability of food security, βj's are parameters to be estimated, X's are explanatory variables while β0 is constant term.

In equation (6.3) the dependent variable is in log odds, by rearranging the equation, the resultant logistic regression can be interpreted in term of probabilities instead of log odds or odds using the equation:

$$P_i = \frac{e^{(\beta_0 + \sum_{j=1}^{k=10} \beta_j X_{ij})}}{1+e^{(\beta_0 + \sum_{j=1}^{k=10} \beta_j X_{ij})}} \quad \text{..... (6.5)}$$

III. RESULTS AND DISCUSSION

3.1 Descriptive statistics results

3.1.1 Household's characteristics

Head of households in the Gezira Main have the highest mean age, education level, years of farming experience and long market distance, 53.9 years, 7.9 years, 24.8 years, and 5.97 Km, which are significantly different from the other location Managil Extension (t = 2.03 **), (t = 2.67 ***), (t = 1.7 *) and (t = 1.8 *), respectively. An observation of the educational status indicates that significant difference was found between two locations. The average years of education of heads are higher for household in the Gezira main than for Managil Extension.

3.1.2 Cropping pattern

The main crops produced in the Gezira scheme are cotton, groundnut, wheat and sorghum, in addition to minor crops such as vegetables. Cotton is considered the main cash crop in the Gezira scheme. Cotton grown in the scheme since the scheme began as a

pilot project for cotton production in 1911. Sorghum is considered as a main stable food for most of the farmers in the Gezira scheme and in the Sudan. It is produced in the scheme mainly for local consumption and the excess amount is sold in local markets. Wheat is a winter crop grown in the Gezira scheme as an import substitute. Groundnut is a summer crop grown in the scheme as a second cash crop.

Table 1: Socio-economic characteristics of farm households categorized by location

Variables		Gezira (120)	Managil (80)	T-value
Age of HH (yrs)	Mean	53.9	50.3	2.03**
	Sd	12.5	11.04	
Education of HH (yrs)	Mean	7.9	6.1	2.67***
	Sd	5.2	3.7	
Family size (persons)	Mean	6.7	6.6	1.04
	Sd	1.6	1.4	
Farmer experience (yrs)	Mean	24.8	21.8	1.7*
	Sd	12.6	11.5	
Dependency ratio	Mean	0.38	0.39	0.79
	Sd	0.19	0.18	
Market distance (km)	Mean	5.97	4.9	1.8*
	Sd	3.9	3.8	

Source: own data, 2014. *, **, *** indicates significant level at 10%, 5% and 1% respectively.

The basic unit in the Gezira scheme called “hawasha”, which is four feddan in the Gezira Main and three feddan in the Managil Extension under one crop, cultivated in rotation. Now a five-course rotation is adopted. The farmers possess five hawasha. One *hawasha* for cotton, sorghum, groundnut, wheat and fallow. Table 2 describes the total area and the area under each crop in the rotation in the two locations.

The production of field crops had highly fluctuated during the last years. Table 3 below review the main crops productivity in kilograms per hectare in the two locations. According to the t-Test, all crops in the two locations showed significant differences. Seeing that productivity of wheat, sorghum and groundnuts in Gezira Main were highly significant difference from the Managil Extension location; (t = 2.9***), (t = 7.3***) and (t =3.3***) respectively.

Table 2: Average cultivated land/ha by food and cash crops categorized by location

Areas		Gezira (120)	Managil (80)	Mann-Whitney z-value
Total area (ha)	Mean	9.10	5.99	- 12.43***
	Sd	2.65	1.29	
Cotton area (ha)	Mean	1.99	Nc	-
	Sd	0.64	Nc	
Wheat area (ha)	Mean	1.53	1.36	- 2.94***
	Sd	1.27	0.68	
Sorghum area (ha)	Mean	2.15	1.47	- 8.70***
	Sd	0.81	0.82	
Groundnuts area (ha)	Mean	1.18	1.41	- 0.168
	Sd	1.04	0.56	

Source: own data, 2014. *** indicates significant level of 1%.

Table 3: Average yield of food and cash crops/kg categorized by location

Crops		Gezira	Managil	T-value
Cotton	Mean	665.2	Nc	-

	Sd	107.5	Nc	
Wheat	Mean	1742.8	1530.7	2.9***
	Sd	500.8	429.5	
Sorghum	Mean	2035	1417.3	7.3***
	Sd	587.3	565.6	
Groundnuts	Mean	1879.9	1455.9	3.3***
	Sd	796.4	610.03	

Source: own data, 2014. *** indicates significant level of 1%

3.1.3 Source of income

Farm income is the difference between the gross receipts from farm production (cash, food crops and livestock) and production expenses. Off-farm income obtained from many sources, such as trading, other secondary jobs, and working in the scheme, savings, remittances and gifts. Off-farm income has two important effects for households. First, it provides more liquidity, which allows for having more working capital in the short term and more investments in the long run. Second, it helps to diversify income and to have more stable income when the agricultural sector faces problems (Waldemar, 2004).

Table 4. Presents the disaggregated income from the various sources for the two locations household in Sudanese pound (SDG), calculated in respective prices for the season 2008/09. The results illustrate that, statistically significant differences between the farming income (crops and livestock) and the income from crops (cash and food crops) between the two location categories, Gezira Main households obtained highest income because 33.3 percent of the Gezira Main farmers cultivate cotton as cash crop, the differences was shown by the Z-test (Z = 3.46***), (Z = 4.27***), respectively. Table 4.10 shows that, the share of farming income from crops sale was 59.6 percent and 40.4 percent from livestock. Income from non-farm activities (off-farm income) is the dominant income source for the two locations farm households. The income earned from second occupation of the head of the household is significantly different between the two locations (Z = 4.03***). Furthermore, the income from asset rent is significantly different between the two locations (Z = 4.86***).

3.1.4 Food expenditure pattern

In this section, descriptive analyses of the food and non-food expenditure patterns of household in the study area were discussed separately. Food security at the household level is not only affected by the composition and quality of the daily food but also the quantity and seasonal availability of stable foods and the lack of diversified food. There are three different ways of obtaining food items in the Gezira Scheme; these are production, transfer (exchange or work for food) and purchase. Total expenditure refers to the money paid by the head of household and their members to cover the cost of food consumption.

Table 4: Sources of income/SDG categorized by location

Income source		**Gezira (N=120)**	**Managil (N=80)**	**Mann-Whitney z-value**
Cropping income	Mean	2370.2	1575.4	4.27***
	Sd	1300.4	1174.3	
Livestock income	Mean	1216.6	1612.2	1.05
	Sd	1119.6	1233.1	
Farming income	Mean	2615.6	1863	3.46***
	Sd	1506.1	1445.9	
Occupation income	Mean	4974.9	3326.3	4.03***
	Sd	1991.3	1361	
Asset rent income	Mean	4493	3196	4.86***
	Sd	1438.5	1293	
Non-farm income	Mean	5747.2	4437.3	0.766
	Sd	2770.7	2141.9	
Remittance	Mean	3698	4200	1.14
	Sd	1649.2	1530	
Total income	Mean	7362.1	6427.7	1.69*
	Sd	3971	3536	

Source: own data, 2014. *, *** indicates significant level of 10% and 1% respectively

3.1.5 Food expenditure pattern

In this section, descriptive analyses of the food and non-food expenditure patterns of household in the study area were discussed separately. Food security at the household level is not only affected by the composition and quality of the daily food but also the quantity and seasonal availability of stable foods and the lack of diversified food. There are three different ways of obtaining food items in the Gezira Scheme; these are production, transfer (exchange or work for food) and purchase. Total expenditure refers to the money paid by the head of household and their members to cover the cost of food consumption.

Table 5 shows the average expenditures for food and non-food commodities among the household in the two locations and the share of different expenditure items to the total expenditure. The Table shows that expenditures on food items are high compared to the expenditures for non-food items. Also it shows highly significant different between two location in food and non- food average expenditures (t =13.8***)and (t = 9.4***) respectively. The expenditure on food and non-food in the Gezira Main is high compared to Managil Extension. Total food and non-food expenditure share in the Gezira scheme during season 2008/09 accounted for about 61.1 percent and 38.9 percent from the total expenditure, respectively. Also all household spent the highest part of their income on food needs as represented by 61.8 and 59.8 for Gezira Main and Managil respectively. The statistical test showed statistically significant differences in the relative expenditure share for the most of the various commodities in the two locations. This is an indication of differences in the behavioral expenditure patterns of the respective sampled household. Most of the households were found to allocate large portion of their food expenditure in vegetables (23.5), meat (19.8), milk (18.7), sugar (15.1), and edible oil (10.6). T-Test showed significant statistical differences between the two locations. Also, the most important non-food expenditure is education (24.7), social participation (20.9), health (19.1), transportation (18.8) and water (10.9). T-Test showed statistically significant differences in the relative non-food expenditure share between the two locations.

Table 5: Share of food and non-food expenditure/SDG categorized by location

Food and non-food	**Gezira**	**Managil**	**T-value**
T. food expenditure	2746.6 (347.9)	2015.2 (393.1)	13.8***
T. non-food expenditure	1829.8 (299.6)	1416.1 (310.1)	9.4***
Total expenditure	4576.4 (496.9)	3431.3 (545.3)	15.3***
Food expenditure %			
Cereal	9.1 (4.6)	8.3 (4.6)	1.2
Vegetables	21.5 (4.7)	26.7 (8.7)	5.5***
Meat	18.3.4 (2.9)	23.3 (4.7)	8.3***
Milk	17.4 (3)	21.4 (2.8)	6.5***
Sugar	13.1 (2.2)	18.3 (3.9)	12.3***
Oil	9.2 (1.3)	13.2 (2.9)	12.8***
Tea and coffee	7.4 (3)	7.1 (2.8)	0.68
Total food expenditure (%)	**61.8** (6)	**59.8** (7.8)	2**
Non-food expenditure %			
Fuel	10.8 (2)	12.7 (2.9)	5.3***
Electricity	14.3 (4.5)	14.5 (5.7)	0.2

Water	10.1 (1.7)	12.1 (3.2)	5.5***
Education	21.8 (7.2)	29.3 (11.1)	4.8***
Health	20.3 (6.1)	16.7 (6.)	3.1***
Clothing	15.6 (3.6)	17.4 (6.1)	1.5
Transportation	20.5 (6.2)	17.4 (10.1)	1.4
Social participation	18.7 (5)	22.9 (6.4)	4.4***
Total non-food expenditure (%)	**38.2** (4.5)	**40.2** (6.3)	1.8*
Total expenditure	**100**	**100**	

Source: own data, 2014. *, **, *** indicates significant level at 10%, 5% and 1% respectively

3.1.6 Food consumption patterns

Food consumption patterns vary from area to another, it could be determined based on consumption of different food items. Household food consumption depends on amount of production and the ability of household to purchase food from market. Accordingly, food consumption based on food availability, household income and purchasing power of households.

The quantity of food consumption by the farm household during a given period (week or month) is used to estimate the average daily food consumption. The food consumption pattern is showing what quantities the food basket of an individual or households can afford (Iyanbe, 2009 found in Abdalla, 2012). Table 6 shows the average of daily food consumption (g/day). In the two locations of the Scheme, the average daily consumption of cereal food is significantly different between the two locations, it means that cultivation and consumption of traditional food is higher in the Gezira Main. The average daily consumption of vegetables is significantly different among households in two locations. Also the consumption of milk is significantly different among households in two locations. The average consumption of beans and eggs are significantly different between the two locations.

The average daily consumption of sugar is significantly different between the two locations. The statistical test of table shows significant difference in the average food items consumption between the two locations, most of the food items consumption are higher in the Gezira main rather than Managil extension this may be due to the high average income in the Gezira main.

Table 6: Average of food items consumed by Households (g/day) in two locations

Food items	**Gezira (120)**	**Managil (80)**	**T-value**
Cereal	3361.2 (1321.4)	2991.3 (1082.1)	2.2**
Vegetables	337 (53.1)	368.4 (64.1)	3.5***
Meat	107.9 (10.6)	106.1 (17.9)	1.01
Milk	576.1 (58.4)	602.3 (57.1)	1.9*
Fruits	170 (58.8)	156.2 (70.9)	0.58
Oil	228.9 (43)	232.8 (41.4)	0.130
Beans	78.9 (20.2)	60.7 (21.9)	4.3***
Eggs	16.3 (3.7)	12.4 (4.2)	1.6
Sugar	441.4 (34.3)	451.7 (7.5)	1.3**

Average of food items (Kcal/day)	2846.6 (1035.6)	2420.2 (704)	10.19***

Source: own data, 2014. *, **, *** indicates significant level at 10%, 5% and 1% respectively.

3.1.7 Dependent variables

The dependent variable is Household Food Security (HFS) status. Consumption based rather than income-based measure of HFS status is used in this study. Consumption is preferable to measure HFS than income because it is less vulnerable to seasonality and life-cycle, less vulnerable to measurement errors because respondents have less reasons to lie, it is closer to the utility that people effectively extract from income, and for the poor most of income is consumed, (FAO, 2002).

The HFS status was determined using the consumption approach based on actual analysis conducted at the food department, Ministry of Health.

Following this approach, household food security status was set on the basis of the caloric content of consumed food items. To do this, data collected on quantities of food are expressed in term of their caloric content, using a factor that converts quantities of edible portions into calories. For each food item a caloric content value was assigned based on the (Sudan food composition tables, (1986). Total Net Calorie (TNC) was estimated based on the total edible portions of weights of consumed food items for each household.

Due to differences in household compositions in terms of age and sex, there was a need to adjust the household size to adult equivalent household size. Adult equivalence was developed by World Health Organization (WHO, 1983) considering the nutritional requirements of an individual by age and gender. Adult equivalence table (Table A1 (Appendix A) is used as a reference to calculate adult equivalent household size in this study.

Finally, the HFS Status was defined based on the consumption per adult equivalent per day. This is given as:

$$HFSi = \frac{\text{TNC consumed by HH in one day}}{\text{Adult equivalent HH size}}$$

where i =1, 2,....., 200..... (6.1)

The per capita daily calories intake requirement for the Sudan population is 2,395 kcal/capita/day (Musaiger, 2002).

Households whose consumed calories were found to be greater than their calorie requirement were regarded as food secure and assigned a value of 1, while households who are faced with calorie deficiency during the study year were regarded as food insecure and they were assigned a value of 0. Hence, the dependent variable, food security status of the *ith* household, was measured as a dichotomous variable:

$Yi = \{1, HFS \geq 2395$ *Kcal (Food secure)*

$\{0, HFS < 2395$ *Kcal (Food insecure)*

Where Yi is food security status of the *ith* household, i is 1, 2…….. 200

3.1.8 Explanatory variables

Based on food security literature and the forgone analysis related to the production and consumption demand theory, the relevant independent variables in the food security model could be described. Most of these variables are either in continuous or dummy form and measured using appropriate techniques. Table 1 summarized the explanatory variables and their expected signs, these variables are categorized into four groups: location variables, human capital, household assets and income provision.

Location variable: a dummy variable of geographic characteristics was included to account for differences in access to food between the two locations.

Human capital: is constitutes factors such as family size and education, (Afari, 2006).

Household size indicates both the household labour supply and its food requirements. Food requirements increase with the number of persons in a household and hence a negative effect is expected.

Education level, measured by the number of schooling years, is expected to have a positive impact on the food security status of household through improved access to market information and price signals.

The gender of the head of household in this study, male-headed household was expected to be more food secure than female-headed households. A dummy variable was used to denote this variable.

Household asset and access variables:

This variable refers to the value of total assets owned by a household. For a given income fluctuation, food consumption could be stabilized through changes in assets. Hence, the more liquid assets the household has, the better its access to credit and to have investment activities.

The effect of *livestock rearing* on food security is difficult to predict. Thus, the value of livestock is expected to be positively associated with food security.

Hiring out of labor by some household may reflect the lack of adequate purchasing power to meet food needs as the return to hired labor are relatively low compared to an investment in the household own production. Hence this variable was included in the model to see its effect on the food security status.

Miscellaneous income (remittances and rents) is important factor that may influence the food security status of household ability to access the necessary capital for farm activities.

Cultivation of cash crops cotton and groundnut are important factors that may influence the food security status. Cultivation of cash crops would increase the household income then will improve food security status. So this variable is expected to have positive effect on food security.

Off-farm occupations are essential sources of household income. Accordingly, it would have positive effect on the food security status through increasing household income.

Table 7: Explanatory variables used in analysis and expected signs

Variables	Units of measurement	Expected sign
Dependent variable		
- Dummy variable	1= Gezira, 0 = Managil	+/-
Human capital		
- Household size	Number of persons	-
- Education level of head	Years	+
- Gender of head	1= male, 0 = female	+
Assets and access variables		
- Livestock rearing	1=Yes, 0 = No	+/-
- HH hiring-out labor	1=Yes, 0 = No	+/-
- Miscellaneous income	1=Yes, 0 = No	+
Income and crops provision		
- Cultivation of cotton	1= Yes, 0 = No	+/-
- Cultivation of groundnut	1= Yes, 0 = No	+/-
- Off-farm occupation	1= Yes, 0 = No	+

IV. EMPIRICAL RESULTS AND DISCUSSION

For the purpose of this study, the logit model is used with the aid of STATA version 10.0. The proportion of food secure households is higher in the Gezira Main (55.8%) than among Managil Extension (48.8%).

With regards to the model characteristics, the likelihood ratio chi-square statistic was used to test the dependence of food security on the selected variables in the model. The model chi-square statistic was 28.18 and highly significant at 10 degrees of freedom with a maximum likelihood regression model fit of (0.10). The model chi-square shows a significant association between the dependent and independent variables. The model predicts the food security status of (53.5) of the sampled household.

Among the ten factors considered in the model, five are found to have a significant impact in determining household food security (tables 6.4 and 6.5). These are labour hire out, miscellaneous income, cotton cultivation, family size and groundnut cultivation.

Table 8: Determinants of factors effecting food security in two locations under study

Explanatory variables	**Coefficient**	**Std. Err.**	**Level of Sig.**	**Odds Ratio**
Education (yrs)	0.0171	0.049	0.35	1.017
Household age (yrs)	0.0018	0.018	0.10	1.002
Household size (persons)	- 0.2279	0.102	1.77*	0.796
hiring-out (dummy)	-1.1242	0.139	2.61***	0.325
Miscellaneous income (dummy)	0.9847	0.982	2.68***	2.677
Cotton cultivation (dummy)	1.2142	1.635	2.50**	3.367
Groundnuts cultivation (dummy)	0.7209	0.818	1.81*	2.056
Livestock rearing (dummy)	0.2025	0.415	0.60	1.224
Off-farm occupation (dummy)	0.2842	0.442	0.85	1.328
Location (dummy)	- 0.3486	0.291	0.84	0.705
Con_	0.7744			

LR chi2(10)	24.46			
Prob > chi2	0.0065			
Pseudo R2	0.101			
No. of observations	195			
Log likelihood	-120.78			

Source: own data, 2014. *, **, *** indicates significant level at 10%, 5% and 1% respectively

Hiring-out labour has positive impact on household food security with significant level of 1% (if household adapt to hire out his/her family labour on other farms that might increases the probability of being food secure by 2.64. This result contradicts the findings obtained by Afari, (2006) in Ghana.

The result also indicated that *miscellaneous income* has positive impact on household food security. As income from miscellaneous sources increases, the probability of food security increases by 2.677with significant level of 1%. This result points to the importance of income generated from sources other than farm activities. However, during the survey it was found that more than 42% of household are likely to work in other occupation than agriculture.

A positive and significant relationship is found between cultivating of cotton and the probability of food security, implying that the probability of food security increases with cultivating cotton. The effect of cultivating cotton will increase the probability of food security by 3.367.

cultivation of groundnut has positive relationship with food security. This means that cultivating of groundnut will increase the probability of food security by 2.056.

Household size has a positive and significant relationship with the probability of food security, implying that the probability of food security increases with family size. Each additional increase in household size increases the probability of food security by 0.796. The result contradicts the findings of Abdalla (2012) in Sudan and Afari (2006) in Ghana.

Other remaining variables such as age of farm household, education level of farm household, livestock rearing, off farm income and geographical locations were not significant but had positive signs. This result suggests that farm households have advantageous of food security along with increasing age, years of education, livestock rearing and off farm income.

V. CONCLUSION

In this study, logistic model is used to examine the determinants of food security within the surveyed area. The results from the logistic regression analysis showed that, the most important food security determining factors included: miscellaneous income, hiring out of labour, cultivation of cotton, household size and cultivation of groundnut. The results did not show any evidence that, the cultivation of food crops was a sufficient for improving food security status of households. In general, households in the Gezira Scheme were more likely to be food secure when they have more access to capital through, cultivated cash crop, hiring-out labour and miscellaneous income.

REFERENCES

[1] Abdalla, S. S. (2012). Food and Nutrition security among the rural household in the dry land sector of Sudan. Margraf Publishers Germany GMbH, 2012. ISBN 978-3- 8236-1631-3.

[2] Adam, M. A. (1996). The policy Impacts on Farmers' Production and Resources Use in the Irrigation Scheme of Gezira Sudan. Ph.D. Thesis, Germany.

[3] Afari-Sefa, V. (2006). Agricultural Export Diversification, Food Security and Living Conditions of Farmers in Southern Ghana: A Microeconomic and Household Modeling Approach; Farming and Rural Systems Economics, Margraf Publishers, Vol. 81, (ISBN: 3- 8236-1490-8), Weikersheim, Germany.

[4]] Ahmed, A. E. (1997). Productivity and Resource Allocation Efficiency of the Major Field Crops in the Gezira Scheme. Unpublished M. Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.

[5] Barnett, T. (1997). The Gezira scheme: An illusion of development. Frank cass, London.

[6] Boutros, J. Z. (1986). Sudan Food Composition Tables, 2nd edition.National Chemical laboratories, Ministry of Health, Sudan.

[7] Demaris, A. (1992). Logit Modelling: Practical Applications, International Educational

[8] FAO, (2002). Food and Agricultural Organization. The State of Food Insecurity: Report of Food and Agricultural Organization, Rome, Italy.

[9] FAO, (2003). The Special Program for Food Security: Responding to New Challenges. Rome.

[10] Field, A. (2005). Discovering statistics using SPSS; London: Sage Publications.

[11] Hill, R. C., Griffiths, W. E. and Judge, G. G. (2001).Undergraduate Econometrics.2nd ed. John Wiley & sons.Inc.,New York

[12] IFAD, (2004).Western Sudan Resources Management Programme. Report on Households Survey. The Three States of Kordofan region.

[13] Musaiger, A. O. (2002). "Diet and Prevention of Coronary Heart Disease in the Arab Middle East Countries." Medical Principles and Practice 11 (Suppl. 2): 9–16.

[14] Mirghani, I. M., I. A. Adam, T. S. Elhaj, and M. M. Salih, (2002). Financial Report on the Assessment and Evaluation of credit and Marketing development in A/Hakam Block. Sudan Gezira Board, Planning and Socio-economic Research Administration, Sudan.

[15] United Nations. (1975). Report of the World Food Conference, Rome 5-16 November 1974. New York.

[16] WHO, (1983). Measuring change in Nutritional status.Guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups, Geneva.

[17] World Bank, (2000). Sudan Options for the Sustainable Development of the Gezira Scheme, Sector Report, No. 20398.SU.

[18] World Bank, (1986). Poverty and Hunger: Issues and Options for Food Security in Developing Countries. Washington DC. The World Bank

AUTHORS

First Author – Omima A. Mirghani, Department of Agric-Economics, Faculty of Agriculture, Omdurman Islamic University, Sudan
Second Author – Abdelateif H. Ibrahim, Department of Agric-Economics, Faculty of Agriculture, University of Khartoum, Sudan
Third Author – Abdelaziz A. Hashim, Agricultural Economics and Policy Research Centre, Khartoum North, Shambat, Sudan
Fourth Author – Awad Elkarim S. O. Khalifa, Institute of Gum Arabic Research and Desertification Studies, University of Kordofan, Sudan