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Determinants of Household Food Security Status in Sudan, White Nile State

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ABSTRACT

Numerous nations encountered food insecurity. Sudan is a country where food insecurity persists as a significant problem due to several issues. Despite numerous studies have been conducted to evaluate household food security using various methodological approaches, assessing the status of household food security remains necessary and essential, given the unique characteristics of different regions, household traits related to food consumption, and variables influencing food security. The aims of this study are to evaluate food security utilizing the Food Consumption Score (FCS) as a proxy measure and determine the factors that influence food security. A sample of approximately 330 households was selected from the White Nile State in Sudan. Data were collected using a structured household questionnaire and a module of the Food Consumption Score (FCS) questionnaire. Multinomial logistic regression (MLR) was employed to analyze the factors affecting food security. The FCS results categorize households into three groups: food insecure (33%), somewhat food insecure (47.3%), and food secure (19.7%). The results of MLR indicate that household size, agriculture expertise, and secondary occupation are the primary factors that significantly influence food security. The odds ratios of 87.2%, 92.8%, and 41.8% indicate a higher likelihood for households to transition from being food insecure to becoming food secure. The study suggests for

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educating households regarding the nutritional value of their food and strengthening the role of extension services. Ultimately, improve food security by disseminating knowledge and information via awareness initiatives conducted by the government and various food organizations.

Keywords: Food Consumption Score (FCS); Multinomial Regression Logistic Model; Household Food Security; Sudan; White Nile State

1. Introduction

Food security is a critical global concern. The World Food Summit[1] defines food security as the condition in which all individuals, at all times, has physical and economic access to adequate, safe, and nutritious food that satisfies their dietary requirements and preferences for an active and healthy lifestyle. Achieving a sufficient degree of food security entails attaining a satisfactory standard across the four pillars of food security: availability, access, utilization, and stability. However, attaining such a level necessitated significant effort, especially in developing countries. Over the past decade, numerous nations have experienced food insecurity due to a range of sophisticated factors, including wars, conflicts, poor agricultural output, adverse climatic conditions, weak governmental policies, and inadequate healthcare facilities. These factors exert a direct or indirect influence on the status of food security at the national, regional, and household levels. Food security at the household level can be evaluated through various metrics. In this context, numerous metrics utilized for evaluating household food security, including dietary diversity, household consumption and expenditure surveys, Food Consumption Score, Household Dietary Diversity Score, Coping Strategies Index, Household Economy Approaches, Household Food Security Survey Module, Household Food Insecurity Access Scale, Household Hunger Scale, and anthropometric measurements[2]. Despite the various metrics for evaluating household food security, a suitable approach primarily relies on the specific pillars of food security being assessed.

According to world statistics of food security, over 2 billion individuals suffer from micronutrient deficiencies, and one-third of the population in developing nations faces food insecurity[3]. Food insecurity currently impacts both urban and rural populations to a significant extent[4]. Despite of -numerous initiatives undertaken by local governments to enhance food security, employing various methodologies[5]. However, food insecurity remains a significant obstacle that all countries worldwide must overcome. Therefore, it is essential to regularly evaluate the extent of food insecurity in emerging nations in order to formulate suitable measures based on the reasons and conditions of the afflicted population.

Sudan is a developing country located in sub-Saharan Africa. Classified as a low-income country, Sudan has grappled with food insecurity issues in recent decades. Sudan experiences a significant degree of hunger, as evidenced by its ranking 103rd out of 125 nations with a score of 27.0[6]. From October 2023 to February 2024, a staggering 17.7 million of the Sudanese population, are facing severe levels of acute food insecurity (37%). The states of Greater Darfur, Greater Kordofan, and Khartoum, which have seen significant levels of organized violence, are home to the most severely food-insecure populations[7]. This statistical results indicate that the crisis in Sudan has deteriorated following the current conflict, necessitating emergency interventions to aid vulnerable populations as an acceptable response.

Currently, numerous studies have been examined the food security status and the factors that have impact on it on various regions of Sudan using different methodological approaches to analyses food security as well as socioeconomics and demographic factors affecting it. Given this, recent study conducted by[8] among the rural Sudanese households was employed a caloric intake approach to categorize the households as either food-secure or food-insecure and analyzed the food security using logistic regression model. Their results pointed out that any increases in rural household income increase the likelihood of food security while any increase in household members decreases the likelihood of food security. They revealed that households in the northern

and western rural areas are less likely to be food secure than those in the eastern rural areas. In contrast, study employed the Household Food Insecurity Access Scale (HFIAS) to gauge the food security in Kassala State was revealed the differences in food insecurity among the households in different areas due to the variations in the distribution of monthly income[9]. In addition, a study conducted in Gadarif State with the goal of assessing the state's food security situation using the USA Household Food Security Survey Module found that age and occupation are the primary variables influencing household food security[10].

Furthermore, a study assessed food security status in the Red Sea State by[11] used the food consumption score (FCS) and investigated the various factors that influence household food security using logistic regression model. They were revealed a positive correlation between food security and factors such as living in urban areas, having an older household head, male leadership, employment, and relying on numerous sources of income. In addition, the food consumption score (FCS) was utilized as a measure of household food insecurity in Kassala State[12]. They used multivariable logistic regression to assess the extent of household food insecurity and identify the factors that contribute to it. They found that a correlation exists between a household's food insecurity and factors such as income, household size, number of children, eating patterns, and avoidance of specific types of food. Therefore, the issue of food insecurity in Sudan necessitates the implementation of strategic measures, as advocated by[13]. The most pertinent strategic measures recommended to tackle the food security issues in Sudan include supporting peace and stability, enhancing the agricultural system, expanding market access, and increasing investments in research.

The aforementioned research indicates that only two studies employed the food consumption score (FCS); nonetheless, they examined the determinants of food security using logistic regression and multivariate logistic regression models. Therefore, it is essential to consistently evaluate the factors affecting disparate levels of food security across various states or regions in Sudan, as these areas exhibit distinct characteristics, household attributes related to food consumption, and determi-

nants contributing to food insecurity.

This study seeks to categorize households according to their food security status by employing the Food Consumption Score (FCS) as a proxy measure and to analyze the determinants affecting household food security status. The findings of this study will aid policymakers, food organizations, and agencies in recognizing and classifying the challenges that substantially affect food security in Sudan.

2. Research Methodology

2.1. Study Area, Sampling and Data Collection

The White Nile State is one of Sudan's 18 states, situated in the country's southern region. The state spans approximately 38,000 square kilometers and comprises nine localities: Ad Douiem, Al Gutaina, Kosti, Rabak, Al Jabalien, Tendulti, Um Remta, Alsalaam, and Guli[14]. The Central Bureau of Statistics predicted that the total population projection would be approximately 2,493,900 individuals in 2018[15]. The state is home to a significant number of refugees, totaling approximately 930,000 individuals (including both refugees and vulnerable locals) who require humanitarian aid. According to[14] approximately 496,000 people in the state will suffer from malnutrition in 2023. The state's community is susceptible to food insecurity when faced with drought or other calamities[16]. These factors led to the selection of the White Nile State as the research study region.

To achieve the study's objectives, a random sample of approximately 330 households was selected from the study region in 2021. A structured household questionnaire gathered the primary data, providing information on the households' demographic and economic characteristics. This included details such as the gender, age, marital status, level of education in terms of years of schooling, primary and secondary occupations, household size, experience in agricultural activities, and monthly income from both agricultural and non-agricultural activities. The World Food Program (WFP) and its partners also developed the Food Consumption Score (FCS) questionnaire module. The FCS module was used to gather data on food intake by households and

their members, and the comparative nutritional value of the different foods ingested. Therefore, the FCS data obtained by surveying households about their frequency of consuming various food items over a period of 7 days. Furthermore, as documented by [17–19], the FCS module collects information about the origins of the food that households consume. Consequently, the FCS module categorizes all food items into eight food groups.

2.2. Analytical Techniques

The food consumption score (FCS) is a proxy measure to assess the food security at the household level. The primary objective of constructing the FCS is to assess the frequency of variety of food items consumed over a certain period of time (often 7 days). The nutritional significance of the various dietary groups determines the FCS. The following formula describes the food consumption score (FCS) [20].

$$FCS = \sum W_i X_i \tag{1}$$

where FCS denotes the food consumption score, W_i represents eight food groups. These are the main staple foods, including cereals, grains, flours, and tubers; pulses and nuts; vegetables; fruits; meat and fish; milk; oil; fat; and sugar.

X_i represents the consumption frequency of different food groups (i) over the past 7 days.

In 2008, the WFP presented an implicit expression of the aforementioned formula for FCS:

$$FCS = W_{staple}X_{staple} + W_{pulse}X_{pulse} + W_{vegetables}X_{vegetables} + W_{fruits}X_{fruits} + W_{meat}X_{meat} + W_{dairy}X_{dairy} + W_{oil}X_{oil} + W_{sugar}X_{sugar} \tag{2}$$

To operate the FCS, follow these steps:

Table 1 illustrates the initial categorization of the various food items consumed by the households into eight distinct food groups. The frequency of food consumption was aggregated for all food items belonging to the same group. The frequency of food consumption was multiplied by the standardized food group weight, which is based on their nutritional value.

1. Calculate the product of each food group's value and weight (refer to **Table 1**).
2. Calculate the weighted scores for each food group

to obtain the FCS.

3. Evaluate the household's food consumption status by applying the following criteria: 0–21: poor food consumption; 21.5–35: borderline food consumption; >35: acceptable food consumption.

Therefore, FCS was derived by adding together the values of the consumption frequency and the given weight. Furthermore, in order to assess the food security status of the household, the FCS achieved in the earlier step is distributed into three categories: 0–21 represents poor food consumption and indicates a group that is food insecure; 21.5–35 represents borderline food consumption and refers to a group with moderate food insecurity; and >35 represents acceptable food consumption and indicates a group that is food secure.

After categorizing the sampled households into three groups according to the Food Consumption Score (FCS), the subsequent phase involves identifying the factors that exert influence on food security status. The MLR model was utilized to identify the primary factors influencing the food security status in the White Nile State of Sudan.

To establish the association between socioeconomic characteristics and food security status the MLR analysis was employed. Multiple independent factors influence one or two dependent variables using multinomial linear regression model [21]. It can handle categorical dependent variables, particularly when there are only two possible outcomes. In the model, the higher-order category treated as a reference for the other outcomes and independent variables. Therefore, the odds ratio used to ascertain the probability of a household achieving food security.

The MLR model is to assess the likelihood of a specific event occurring and the influence of independent variables on these probabilities. The presence of odds signifies the probability of an event's success or failure [4]. The FCS, the dependent variable, determines the food security status (i.e., food insecure, moderate food insecure, and food secure). The literature review indicated that numerous independent variables were considered to assess the food security status. In this study, the independent variables included in the model are age, gender, household size, secondary occupation, educa-

Table 1. The food groups and specific food items that used to compute the FCS for households in the White Nile State of Sudan, 2021.

Food Groups	List of Food Items	Weight
Main staple foods Cereal, Grains Flours, and Tubers	Maize, millet, sorghum, potato, sweet potato, rice, other grains, flour, and food crops such as; pasta, porridge, and "Kisra" (local Sudanese foods made from sorghum flours)	2
Pulse, and Nuts	Beans, chickpeas, lentils and peanuts, other pulses	3
Vegetables	Pepper, tomatoes, carrot, cucumber, okra, eggplant, watercress, other leafy vegetables	1
Fruits	Bananas, watermelon, mangoes, oranges, and other fruits	1
Meat and fish (red and white meat and eggs)	Chicken, beef, Mutton, eggs, and fish	4
Milk	Yoghurt, chees, milk, dairy products	4
Oil/fat	butter, ghee, and other oil	0.5
Sugar	Powder sugar, honey, other sweetness	0.5

tion, the household's monthly income, and experiences in agricultural activities.

As a result, many studies have used the MLR model to assess food security status. Accordingly, study in Nigeria used MLR to interpret the increase in food insecurity due to socioeconomic shocks and social protection during the COVID pandemic[22]. Research conducted by[4] utilized the MLR model to assess the household food security in South Africa. Alternatively, the determinants of rural household's food security in the Sinana district of Ethiopia also identified by using the MLR model[23]. In Bangladesh, the MLR model was used to assess and predict the risk factors influencing food insecurity in low-income households during the COVID-19 lockdown[24]. Research conducted in Nepal used the MLR model to interpret the significant factors affect the food insecurity among the rural households[25]. The MLR model was also applied to suggest a three-category definition of food insecurity[26]. Furthermore, the MLR model used to determine the factors influencing the household's food security status are involved in inland fisheries and those are not[27].

The model used a random variable y_i that assumed different discrete values for j = 1, 2, … L, and the response had L categories that were mutually exclusive and collectively exhaustive[25]. The assumption is that π_{ij} represents the probability that the i-th response belongs to the j-th category, where π_{ij} = Pr Y_i = j; j = 1, 2, … L. Thus, we

set e$\Sigma\pi_L$; j = 1 = 1 for every l, with L − 1 being the total number of categories.

Accordingly, the MLR model depicted the log-odds models for M covariates related with the i-th individual as follows:

$$\ln\frac{\pi_{ij}}{\pi_{iL}} = B_{j0} + \sum_{K=1}^{M} B_{jK}X_{iK}; j = 1, 2\ldots\ldots L - 1 \quad (3)$$

The explanatory variables were ≤ 0 ≤ π_{ij} ≤ 1, j = 1, 2, … L – 1, and X_{ik} (i = 1, 2, … n; k = 1, 2, … M). The conditions of the model β_{j0} and β_{jk} were evaluated using the Newton-Raphson iterative approach, focusing on the highest odds[25]. The equation simultaneously described the impact of X on the above L – 1 logits mentioned before, taking into account the reference category L. The impact had a varied likelihood based on the corresponding reaction, which was computed as:

$$\frac{\pi_{ir}}{\pi_{is}} = \frac{\pi_{ir}}{\pi_{iL}} = \frac{\pi_{is}}{\pi_{iL}} \quad (4)$$

where r ≠ s = 1, 2, … L – 1.

3. Results and Discussion

3.1. Household's Food Security Status

Accordingly, **Table 2** reveals the classification of the households based on FCS. Therefore, about 33% of the households are food insecure (poor food consumption), 47.3% of the households are moderate food in-

secure (borderline food consumption), and 19.7% of the households are food secure (i.e., acceptable food consumption level). Thus, the borderline food consumption group accounts for approximately half of households. [20]

conducted a study in Ghana using FCS to measure households' food security, and found that the poor food consumption category contained higher numbers of households.

Table 2. Food security status in the White Nile State of Sudan according to FCS.

Categories of Food Security	FCS	Frequency	Percent (%)
Food insecure (Poor food consumption)	0–21	109	33.0
Moderate food insecure (Borderline food consumption)	21.5–35	156	47.3
Food secure (Acceptable food consumption)	>35	65	19.7
Total		330	100.0

3.2. Factors Influencing the Household's Food Security Status

Table 3 displays the qualitative factors representing the socioeconomic characteristics of the households in the research region. Males head approximately 54.8% of the households, while females head 45.2%. The proportion of household heads in the first age group (20–30 years) is approximately 16.1%. The proportion of household heads in the second age category (31–40 years) is approximately 41.8%. Approximately one-third (33.3%) of the households have engaged in a secondary occupation.

Table 4 provides a statistical summary of the quantitative variables pertaining to household characteristics in White Nile State. The outcomes display the average education for household heads is approximately 7.29 years. The average household size is approximately 5.44 individuals. Most of households in the White Nile State occupied in agricultural activities. The average length of agricultural experience among household heads is 7.62 years. Conversely, the average monthly earnings from all endeavors amount to 21989.167 Sundanese SDG.

Table 5 underscores the outcomes of the MLR model. The model's adequacy was assessed to determine the extent of improvement in its fit. For this assessment, SPSS software provided both the Nagelkerke R^2 and the Likelihood Ratio Chi-Square Test. The pseudo-Nagelkerke R^2 in the MLR, as described by [28], does not have a definitive interpretation in relation to the variance of the outcome. The Nagelkerke R^2 modifies both Cox and Snell R^2, as its value cannot attain 1.0 as argued by [29]. Hence, the Nagelkerke R^2 value of 0.150

indicates a robust correlation between the independent variables and the dependent variable. The chi-square test was used to assess the overall model it is based on the concept that a p-value below 0.05 indicates a satisfactory fit. The results indicate that the Chi-square value is 46.563, which is statistically significant at a 1% level.

Table 5 indicates that the variable "household size" has a negative relationship and statistically significant with both food insecure and moderate food insecure households at level 10% and 1%, respectively. The odds ratios are approximately 87.2% and 79.4%, suggesting that there is a higher likelihood for households' food security status to transition from being food insecure and moderate food insecure to becoming food secure, respectively. The negative coefficients indicate that when household size increases, both food insecurity and moderate food insecurity will decrease. The outcome is deemed satisfactory, particularly when the household predominantly comprises adult individuals. An expansion in household size could boost household income, hence enhancing food security, particularly when the members having jobs. Numerous research in the literature review have examined the influence of household size on achieving food security. The current result disagrees with the finding of [4, 30]. They demonstrated that smaller household sizes are more likely to attain a condition of high food security. Also, [31, 32] identified an inverse association between family size and food insecurity in Pakistan. Additionally, in Nepal study applied by [33] determined that household size was negatively and statistically significant in relation to food security. A study conducted in Nigira by [34] posited that house-

Table 3. Qualitative variables of the socioeconomic characteristics of the households in White Nile State of Sudan, 2021.

Socioeconomic Characteristics	Frequency	Percentages
Gender		
Male	181	54.8
female	149	45.2
Age		
First age category (20–30)	53	16.1
Second age category (31–40)	138	41.8
Third age category (41–50)	96	29.1
Forth age category (51–60)	43	13.0
Secondary occupation		
Household heads engaged in secondary occupation	110	33.3
Household heads not engaged in secondary occupation	220	66.7

Table 4. Summary statistics of the household characteristics.

Socioeconomics Characteristics	Min.	Max.	Mean Value	Standard Deviation
Education (years of schooling)	1	16	7.29	3.44
Household size (persons)	0	16	5.44	2.56
Experiences in agricultural activities(years)	0	20	7.62	5.79
Monthly income (SDG) [a]	1850	42000	21989.167	7668.103

[a] Local Sudanese's currency.

hold size had a marginally adverse effect on food security. Another conclusion reported by [35] and indicated that households with five or more family members are more likely to experience moderate to severe food insecurity. Typically, an increased number of adults in a home correlates with a heightened likelihood of food insecurity [36, 37]. The composition of households also influences food security. In this regard, a definitive association between the dependency ratio and food insecurity was discussed by [38]. A household with a high dependency ratio, primarily consisting of youth and elderly individuals, is more prone to heightened food insecurity. This is due to their imposition of tremendous pressure on the consumer base while making negligible or no efforts to acquire food. The research opposes the findings of [20]. They indicated that classifying a greater number of household members as exhibiting poor or borderline food intake is more likely than classifying them as having acceptable consumption.

Conversely, the experience of agricultural activities exhibits a statistically significant negative effect at a 1% significance level for both food insecurity and moderate food insecurity. The odds ratios are approximately 92.8% and 93.9%, suggesting that households' food security status is more likely to transition from being food insecure and moderately food insecure to becoming food secure, respectively. The negative coefficients indicate that as agricultural experience increases, both food insecurity and moderate food insecurity will diminish. This suggests having good experiences in agricultural practices leads to increase productivity and hence rise of agricultural income, which in turn improves food consumption and food security. In this context, a comparable consequence posited by [39] emphasized that the enhancement in agricultural output leads to improved food security.

Monthly income is defined as the total amount of money received by individuals in households from various sources every month [40]. The findings indicate that household monthly income has a positive and statistically significant relationship with food insecurity and moderate food insecurity, respectively. The odds ratios are approximately equal to one for both individuals experiencing food insecurity and those with moderate food insecurity. The results suggest that households are more likely to be classified as food insecure or moderately food insecure, as opposed to being classified as food secure, based on their food security status. The positive coefficients indicate that as the household's monthly income increases, both food insecurity and moderate food inse-

curity will rise. This is mostly attributable to insufficient awareness of the nutritional worth of foods and dietary diversity. Furthermore, the inadequate understanding of the judicious distribution of money and the failure to utilize extra income for the procurement of a varied food items may constitute fundamental factors contributing to the escalation of food insecurity.

The research conducted by[40] yielded contradictory results. He argued that income regarded as the principal determinant of food insecurity. Households with higher incomes demonstrate a higher probability of achieving food security compared to those with lower incomes. Moreover, the result contradicts the conclusions drawn by[23]. A negative correlation was identified between total net income and the food security status of households. Moreover, as income increased, the probability of a household facing severe food insecurity diminished. A contrasting study reveals a significant negative correlation between per capita income and household food insecurity[32]. A recent study in Bangladesh indicated that families with a monthly income below 58.96 USD faced increased levels of moderate and severe food insecurity during the COVID-19 pandemic[35].

Conversely, the secondary occupation has a statistically significant negative effect at the 5% level for those experiencing food insecurity and at the 1% level for those experiencing moderate food insecurity. The odds ratios are approximately 41.8% and 38.2%, suggesting that there is a higher likelihood of households transitioning from being food insecure and moderately food insecure to becoming food secure, respectively. The negative coefficient indicates that an increase in the number of households engaged in secondary occupations will lead to a drop in both food insecurity and moderate food insecurity. Transitioning from no secondary occupation to a secondary occupation may increase income from other activities, thereby enhancing food consumption and food security. The result consistent with this conclusion of[4] they found that individuals with employment have a higher likelihood of experiencing food security compared to those without employment. Participating in a job on a full-time basis will enhance the level of food security[38]. The households involved in formal employment demonstrated greater food security in comparison to households engaged in informal employment as mentioned by[41].

The household heads in the age category (20–30 years) have a statistically significant negative impact on moderate food insecurity at a 10% significance level. The odds ratios indicate that households in the first age category (20–30 years) are 23.4% more likely to transition from moderately food insecure to food secure compared to the reference age group (fourth age category, 51–60 years). Conversely, the second age category (31–40) and the third age category (41–50) have a statistically significant negative impact at the 1% level with moderate food insecurity. The odds ratios for the two age categories are approximately 14% and 16.8%, indicating that households with heads in these age groups are more likely to transition from moderately food insecure to food secure compared to the reference age group (fourth age category). The negative coefficients indicate that as the age of the household's head changes from the first, second, or third categories in comparison to the fourth category, there will be a decrease in moderate food insecurity. Study by[4] obtain similar outcome found that young individuals are more likely to have a significantly higher level of food security compared to the elderly. According to[5], younger household heads are more likely to have enough food compared to older household heads. This is because older household heads have more responsibilities, which puts pressure on their available income and increases the chances of experiencing food insecurity. In addition, young individuals are still actively participating in the economy and can partake in profitable activities that generate income. Furthermore, the present study concurs with the findings of the research conducted by[42]. The age of the household head is positively correlated with food security, albeit with a minimal probability of impact. Moreover, the current study supports the findings of[35]. They argued that individuals aged 30 to 40 years and 40 to 50 years were significantly correlated with mild-to-moderate and severe food insecurity in Bangladesh.

Table 5 also shows that gender and education are statistically insignificant concerning both food insecurity and moderate food insecurity status.

Table 5. Determinants of the Household's Food Insecurity Status in the White Nile State of Sudan, 2021.

Food Insecurity Level		*B*	Std. Error	Wald	Sig.	Exp (B)
Food Insecure	Intercept	3.439	1.271	7.317	0.007	
	Household size	−0.137	0.068	4.021	0.045	0.872
	Experiences in agricultural activities	−0.075	0.029	6.767	0.009	0.928
	Education	−0.013	0.048	0.071	0.790	0.987
	Total monthly income	0.000	0.000	3.012	0.083	1.000
	Gender	−0.121	0.331	0.132	0.716	0.886
	Secondary occupation	−0.872	0.380	5.272	0.022	0.418
	First age category (20–30)=1	−0.163	0.807	0.041	0.840	0.850
	Second age category (31–40)=2	−0.787	0.693	1.292	0.256	0.455
	Third age category (41–50)=3	−0.550	0.711	0.600	0.439	0.577
	Fourth age category (51–60)=4	0 [b]	.	.	.	.
Moderate Food Insecure	Intercept	4.710	1.221	14.869	0.000	
	Household size	−0.231	0.067	11.938	0.001	0.794
	Experiences in agricultural activities	−0.063	0.028	5.148	0.023	0.939
	Education	0.013	0.046	0.082	0.774	1.013
	Total monthly income	0.000	0.000	9.622	0.002	1.000
	Gender (male)	−0.204	0.322	0.403	0.526	0.815
	Secondary occupation	−0.964	0.370	6.779	0.009	0.382
	First age category (20–30)=1	−1.451	0.761	3.639	0.056	0.234
	Second age category (31–40)=2	−1.963	0.641	9.387	0.002	0.140
	Third age category (41–50)=3	−1.785	0.661	7.293	0.007	0.168
	Fourth age category (51–60)=4	0 [b]	.	.	.	.
Model Summary						
X^2		46.563				
Cox and Snell R^2		0.132		Sig.		0.000
Nagelkerke R^2		0.150				
McFadden R^2		0.068				

[b] This parameter is set to zero because it is redundant.

4. Strength and Limitation and Future Research

The strengthens of this study represent in providing in-depth analysis for the determining the factors influencing food security in Sudan with considering the food consumption score (FCS) as proxy measurement. Thus, the households were categorized into three groups: food secure, food insecure and moderate food insecure. Therefore, by analyzing the determining the factors of food security would help the policymakers in designing and implementing programs that seek to solving the problem of food insecurity in Sudan according to the characteristics of each groups.

The limitation of this study is that it considers the state of household food security in relation to a specific region of Sudan, the White Nile State. Thus, different regions in Sudan may entail special considerations. Additionally, food security is analyzed using food consumption Score (FCS) as a proxy measure. Therefore, assessing the food habits would be essential for better understanding food insecurity problem and hence; provide special recommendations to achieve the effective level of interventions.

5. Conclusions

The results indicate that household food insecurity is affected by multiple factors. Accordingly, larger households, comprising adults with experience in agricultural activities and secondary occupations, are more likely to achieve food security. Nonetheless, the increase in monthly income led to elevated food insecurity and moderate food insecurity. This results from a deficiency in comprehending the nutritional worth of foods and the importance of food variety. The households also lack adequate understanding of the logical distribution of their resources to acquire a variety of food items. Generally, the results underscore the necessity of incor-

porating all these factors in any program aimed at enhancing household food security in the future. The policy recommendations emphasize educating household members about the nutritional importance of their dietary intake and encouraging them to diversify their food choices and consumption habits to mitigate issues related to food poverty and malnutrition, which are significant concerns that contribute to resolving this problem. Strengthening the role of extension services is essential for improving agricultural systems in the study region and other areas of Sudan. The extension services will offer guidance and support to households, facilitating the adoption of modern agricultural practices. This will consequently result in enhanced agricultural production and, hence, more income generation. Engaging in supplementary activities is recommended to enhance household income and favourably impact food consumption and food security. Increasing food intake necessitates comprehending the significance of rational income distribution and utilizing increase in income to purchase a diverse array of meals. Conduct a nutritional assessment and analysis that reflects an awareness of the household's food consumption patterns is very important. Furthermore, the government and various food organizations play a crucial role by implementing awareness programs to enhance the food consumption, thereby enhancing food security in the research area and across Sudan.

Further studies may concentrate on categorizing household food insecurity throughout different regions of Sudan, so contributing to addressing this issue. Future research ought to evaluate household coping strategies associated with different degrees of food insecurity. Furthermore, incorporates the evaluation of food security via food consumption and dietary patterns into future studies.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Conflict of Interest

Author disclosed there is conflict of interest regarding the publication of this article.

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