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Spatial Distribution of Food Poverty Incidence in Juba Town: A geo-statistical Assessment

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Abstract Food and nutrition security survey based on a representative sample of the population of Juba Town was conducted from October to November 2010. The survey covered four localities: Gudele, Juba na Bari, Kator and Munuki. Daily calorie intake using a one day 24-hour diet recall varied between 500 to 3,500 Kcal as a function of monthly income. Spatial distribution of food poverty incidence as well as daily calorific values were geo-statistically analyzed using a GS+^{TM} Version 9 software. Results showed that about 13.2% of the households with incomes less than 500 SDG/month were severely food insecure with constant hunger,41.5% of the households with incomes between 350-800 SDG/month were food insecure with moderate hunger; 35.8% of the households with incomes between 850-1850 SDG/month were food insecure but without hunger; and 9.4% of the households with incomes between 1,850 and 4,000 SDG/month were food secure. Isotropic variogram of food poverty incidence showed a 46.6% moderate spatial dependency with a relatively low correlation coefficient of r^2=0.15 and a range A_0 of 8.8 km suggesting a wide radius of even food poverty levels across much of Juba Town. Meanwhile the estimated daily per capita calorific values also showed moderate spatial dependency of 60.3% and a small range A_0at 2.3 km. Food poverty incidence at low correlation coefficient r^2=0.02 positively correlated with family size and negatively correlated at r^2=0.17 with the per capita food consumption. Monetary indicator was used to assess food poverty with the Gini coefficient at 0.32. This unequal income distribution suggested the vulnerability of most households to food insecurity. However, most low income households with less freedom of choice easily compensated their dietary diversity and calorific values through appropriate food preparation methods.

Keywords: *daily calorie intake, dietary diversity, food security, food poverty mapping, Gini coefficient, isotropic variogram*

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1. Introduction

Food poverty may be defined as 'the inability of an individual or household to afford, access adequate quality and quantity of food daily to be able to lead a healthy and socially reasonable life" [1,2]. Anchored to food security, it is better understood within the broader context of poverty and deprivation. Often, both food poverty and food deprivation are interchangeably used to imply food shortage. Several thematic studies on the estimation of food poverty have differentiated approaches like the Minimum Subsistence Basket (MSB) [3] the Household Budget Survey (HBS) [4]. The latter employs normative indicator that is measurable (e.g. daily food expenditure based on disposable monthly income) [5] while the former employs cost estimate for a food basket that would satisfy the daily nutrient status of an individual or household. This food poverty line was set at 2.43 SDG (approximately $1/d/capita) for the whole Sudan prior to independence of South Sudan in July 2011. Because food poverty is measurable, it therefore can be perceived as a scalar quantity that has both spatial and temporal features. It is temporal or transient and time-dependent [6] because households or individuals may under certain circumstances successfully obviate such food poverty challenges through coping strategies e.g. self-employment, getting well-paid jobs, seasonal jobs etc. Food deprivation in a household is a measure of the extent or depth of food insecurity and demonstrates how far off individuals or households are from the food poverty line. This deprivation depth manifests itself as hunger where especially in urban settings, a household or individual is constrained by the inability to mobilize financial resources to buy enough food. This however, is less relevant for rural areas where households have low disposable incomes and are, in terms of food production self-reliant and food secure. Lately, nutritionists and other international agencies such as IFPRI, UNICEF and FAO have recognized the need to merge "food security" with the "nutrition security" into the "food and nutrition security" as a holistic and more expounded approach [7].

Food insecurity and hunger in Juba Town and South Sudan at large cannot be captured by any single variable.

The main food security variables identified by [8] are in context similar to those that occur in South Sudan: massive population pressure as a result of Internal Displaced Persons (IDPs) migrating from other states to Juba Town, intrinsic poverty due to decades of war, structural and distributional inadequacies between production and consumption areas, less coherent government policies, inability to compensate for shocks during inadequate food supplies, social insecurity and political instability.

In South Sudan however, no studies have ever been conducted to assess the Recommended Dietary Allowance (RDA) for all age groups and its influence on body weight and height. Unpublished reports reveal that most South Sudanese males before the 20 year long civil war were on average above 1.80 m while for females this was 1.70 m. Implications of the serious food and nutrition insecurity during and after the 20-year civil war suggest a 5-10% reduction in height of most adult South Sudanese. Equally, other studies of the [9]WFP on food and nutrition insecurity in South Sudan according to MUAC revealed a 20% acute malnutrition among 15 to 49-year old non-pregnant women, 20% acute malnutrition among 6-59 months old children.

Measuring household food insecurity and deprivation is in itself necessary to be able to assess the extent of experiential hunger and the implications on health and welfare of household or society. However, inherent errors on food security measurement as reported by [10] often occur, especially when using the gross production-purchase-depletion approach of food stocks in a household as a function of time during a 24-hour recall. Other methods of food security measurement include anthropometric methods [11] or using asset ownership, household size and dependency ratio [12].

Conducting a 24-hour recall of intra-household food and nutrition security in Juba Town and South Sudan at large can be a difficult task as this requires comprehensive identification and decomposition of influencing factors, e.g. multiple sources of income among adults in a household, maturation and age variations of household members; individual food preferences and distributional differences, socio-cultural perceptions coupled with child and gender discrimination (*common house wife practice had it that special meat or fish dishes was served exclusively for the husband with house wife and small children sharing the left-over*). Most of the questionnaires used to measure food and nutrition security are carried out for certain adult individuals and often do not reflect the overall food access level of a household including children [12]. The question of assessing food security and hunger requires integrating both objective and subjective indicators that are measurable in time. Objectively, limited financial resources of a household constrain food access, subjectively, though hunger is experiential and can only be expressed by a person feeling it. [13] used the concept of continuum food security for meaningful separation and scaling at both household and individual level as:

i) Food secure — Households that show no or minimal evidence of food insecurity.

ii) ***Food insecure without hunger*** — Food insecurity is evident. But household members show concern about food quantity, quality, supply and management.

iii) ***Food insecure with hunger (moderate)*** — Food intake for adults is reduced to an extent that adults have repeated experiences and sensation of hunger.

*iv)****Food insecure with hunger (severe)*** — Most households with children have reduced the children's food intake to an extent that children have experienced hunger. Adults in households with and without children often have extensive reductions in food intake.

Between 2010 and 2011, with about 25%t growth rate, South Sudan had one of the fastest economies in the region. It´s GDP stood at $1,500 per capita. However, the oil shut down in July 2012 witnessed a slump in growth setting off inflation to a staggering 71%. Despite suchhigh growth rates, over 51% of the population of South Sudan still lives below the poverty line [14].

Several studies on food poverty have focused on intra- and inter-sectoral decomposition, meaning changes in food poverty within specific sectors of the society in time [15], or the growth and inequality decomposition due to economic growth or income changes of households [16,17]. Socio-economic factors play significant roles in expounding food poverty incidences at both the household and community levels of people living in especially economically disadvantaged areas of Juba Town.

Analogous to the mathematical formula for Poverty Incidence or Poverty Rate, P_o used by [18], the FPI here may be referred to as the amount of money per capita/day required to purchase sufficient food for healthy living. In simple terms, it is refers to the total amount of money required by a certain number of persons per household to be able to purchase enough food as compared to the nationally accepted Food Poverty Line, FPL of 2.43 SDG as:

$$FPI = MI - \sum \left[\frac{Total_{\exp}}{N} \right] < y \qquad (1)$$

where, y = the food poverty line
FPI = Food Poverty Incidence
MI = Monthly Income in SDG
N = Number of persons per household
$Total_{exp}$ = Other Total monthly expenses (*e.g. school fees, clothing, loans etc*.)

1.1. Food Poverty Measuring and Mapping Approaches

Juba Town´s consistent food and nutrition insecurity can be better understood within the context of the number of households living below the food poverty line and unable to consume the daily required calorie intake. For most low income households, this is enforced deprivation as they do not possess the financial resources to afford good nutrition. Equally, high income households that are food secure experience voluntary deprivation as they can freely make choices on nutrition insecure food items. Recent studies in developing and low income countries revealed that under-nutrition due to food deprivation led to stunted growth in 50% of under five-year old children in India [19].

In this paper, we approach the estimation of food poverty line directly from the daily per capita food expenditure using a household´s family size as reference. Food poverty lines derived with this approach demonstrate

that persons or households with specific daily per capita food expenditures, regardless of their monthly incomes may be described as food secure or insecure. This paper used the major pillars of food security: *affordability, availability quality and safety* with a few selected indicators adopted in GFSI frame work. On affordability, (*the daily per capita food expenditure*); availability, (*sufficiency in food supply*); quality and safety, (*dietary diversification and nutritional standards*).

The main objective for conducting this research was primarily to:

assess the spatial distribution on food security situation and, find the inter-linkages between monthly income and daily per capita calorie intake of households in the four localities.

2. Methodology

2.1. Study Area

The survey was conducted in four residential areas of Gudele, Juba na Bari, Kator and Munuki of greater Juba Town. The four residential areas with an approximate population of about 40,000 inhabitants, one-tenth of the total population of people currently resident in Juba Town. The geo-reference zero-point for all measured points was set in Kator residential area, close to St. Theresa´s Cathedral. From Kator, the geo-referenced positions and proximities of households in the residential areas of Gudele and Munuki were between 6-12km and between 1-4 km for Juba Na Bari.

Unpublished survey shows the presence of a strong working class mainly government employees and self-employed business persons in the informal sector especially in Gudele, and Munuki. Juba na Bari and Kator are old established localities. The former predominantly a business centre with many government institutions and whole sale markets, while the latter more of low income households.

Research survey as in Table 1, on 63 households was conducted on the 14-21st October 2010 in 18 householdsat Kator residential area, then followed on 22-28th November by Juba na Bari which presumed to be one of the affluent areas of JubaTown. The survey was further conducted on 14-20th on 16 households in Munuki and lastly on the 22-27th November 2010 on 14 households in Gudele residential areas. A Garmin etrex, (Garmin Ltd, USA) a geo-referencing device was used to enter the coordinates and locations of the various households starting from Kator locality. The entered and geo-referenced data were later used as input data for geo-statistical analysis.

Table 1. Numbers of respondents in the different residential areas of Juba Town in 2010

Residential Area	Number of respondents	Interview date
Kator	18	14-21 October
Juba na Bari	15	22-28October
Munuki	16	14-20November
Gudele	14	22-27 November

3.2.1. Data Design, Collection and Sampling

The main tool for data collection was the structured household-based questionnaires and done through the "*in-depth key informant interviews*" with the various respondents in the different residential areas of Juba na Bari, Kator, Gudele and Munuki.

This tool ensured that all respondents were given the same set of questions and their responses expected to be free and honest. Questions that seemed to infringe on one´s own personal ego and self-esteem in terms of monthly incomes or number of dependents were reframed. The questionnaires were administered to household income/wage earners or their spouses and the responses expected to reflect the true individual or family situation, although this is often subject to errors and biases [20].

The target groups comprised of people with varying professions in both public and private sectors and also took account of gender peculiarities. In all the residential areas, a total of 63 respondents answered to the questionnaires. A total survey was conducted randomly in 36 households in Juba town with Gudele10, Kator 13, and Juba Na Bari 13. Given the magnitude of the question on average 4-5households were asked about their livelihoods.

The questionnaires in the survey above all focused on job/profession, net income, daily food expenditure and other household expenses. A 24-hour recall for each household (Table 2) was conducted on the daily eating habits and number of meals per day, number of days per week for meat, vegetable, fruit and salad consumption. The interviews to study the standard of living in relation to food poverty in Juba Town were randomly conducted and limited to one person/house. The survey was done as from October to December in 2010.

Table 2. The food security level and indicators of households in four localities of Juba Town

Food security level	Dietary and nutrition indicator	Estimated meals per day
Food secure	Households that show no or minimal evidence of food insecurity	3
Food insecure without hunger	Food insecurity is evident. However, household members show concern about food quantity, quality, supply and sustenance	2 to 3
Food insecure with moderate hunger	Food intake for adults is reduced to an extent that adults have repeated experiences and sensation of hunger. Strong hunger sensation in children	1 to 2
Food insecure with hunger	Most households with children have reduced the children's food intake to an extent that children have experienced hunger. Adults in households with and without children often have extensive reductions in food intake.	0 to 1

2.2. Data Analysis and Evaluation

Qualitative data was organized into relevant themes: net monthly incomes, net monthly debt increment, family size, types of foods consumed per week, food cost per day, food expenses per capita per day (*poverty index*), other demands and loans. For interpretation, the data were entered onto a MS Excel spreadsheet and thematic-based graphs generated. The analyzed and evaluated thematic data was used to make inferences on possible causal relationships between two chosen variables, e.g. between food expenses and family size.

Food Poverty Incidence FPI, may be described as a "composite index measuring food deprivations in the four

basic dimensions— affordability, availability, accessibility, and usability for a healthy and decent standard of living". This, however, in South Sudanese context was not the case and other indicators or criteria such as accessibility and affordability to food, education, good sanitary facilities, may best be used to assess the poverty index. Two criteria for the Food Poverty Incidence (FPI), used herein are the: daily food expenditure and calorie intake per capita.

2.3. Geo-statistical Mapping

Geo-statistical software GS+^{TM} Version 9 (Gamma Design Software, LLC, Plainwell Michigan, USA) was used to quantify the so tropic spatial variability and construct semi-variogram models for the soil cone index. Spherical, exponential, Gaussian and linear variograms were considered. For the studied localities only the exponential and Gaussian models were selected and the best fitting models based on the values of weighted Residual Sums of Squares (RSS), regression coefficient (r^2) and relative spatial structure indicator (Nugget/Sill) to indicate the spatial dependency were used.

The experimental semi-variograms were produced using the equation:

$$\gamma(h) = \left[12N(h)\right]\Sigma\left[z_i - z_{(i+h)}\right]^2 \quad (2)$$

where γ(h) = semi-variance for interval distance class h;
z_i = measured sample value at point i;
$z_{(i+h)}$ = measured sample value at point i+h; and
N(h) = total number of sample couples for the lag interval h.

The exponential and Gaussian isotropic models were the best-fitted models used to characterize the spatial variability in this study. The exponential isotropic model is given here as:

$$\gamma(h) = C_0 + C\left[1 - \exp(-h / A_0)\right] \quad (3)$$

while the Gaussian isotropic model was given as:

$$\gamma(h) = C_0 + C[1 - \exp(-h^2 / A_0{}^2)] \quad (4)$$

where γ(h) = semivariance for interval distance class h;
h= lag interval; C_0= nugget variance ≥ 0; C = structural variance ≥ C_0, and A_0= range parameter.

Interpolation was performed using both the ordinary kriging and the Inverse Distance Weighting (IDW) methods. The spatial trend was visualized from contour maps.

3. Results and Discussion

Kator and Munuki showed the highest poverty incidence at between 1.55 to 2.33 (Figure 1) and was about 81% of the total population of both localities, while Juba na Bari and Gudele showed poverty incidence between 0.47 to 1.86 and was about 36% of the total population. Poverty levels varied widely from one locality to another within the study area. However, the application of the per household income poverty line showed that all localities of the study area suffer generally from high levels of poverty exceeding 80%.

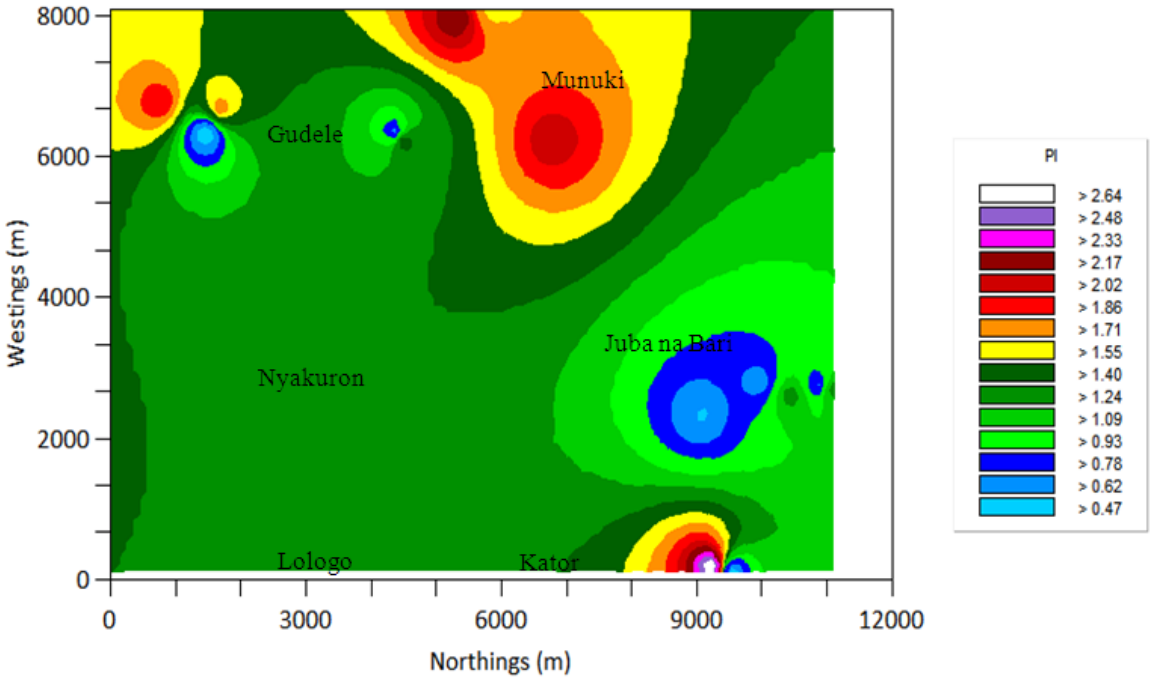

Figure 1. The spatial distribution of poverty incidence of different households in four localities of Juba Town

Spatial analysis of food poverty incidence of the different households using isotropic variogram showed that this had moderate spatial dependency (S=48.6%) with low correlation coefficient r^2=0.15as shown in Figure 2. Spatial dependency is estimated as ratio of nugget to sill with values between 0-25% as strongly spatially dependent, 25-75% as moderately- and over 75% as weakly spatially dependent [21]. It should be noted, that the degree to which spatial correlation was characterized was dependent on the sampling grid size and number of samples. In this study, the spatial structure of food poverty incidence was the same within the range A_0 of about 8.8 km, suggesting the prevalence of more or less uniform poverty levels across large parts of the town.

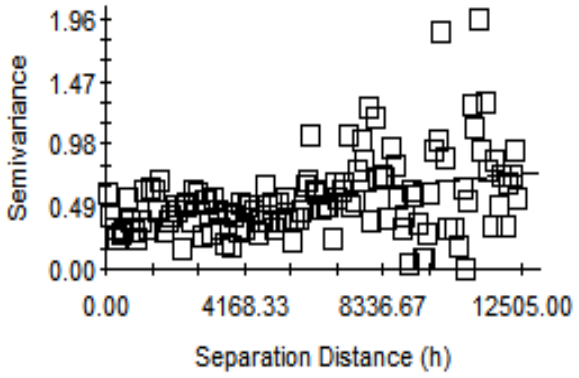

Figure 2. Isotropic variogram for the spatial distribution of poverty incidence of different households in four localities of Juba Town. (Nugget, C_0=0.386; Sill, C_0+C=0.794; Range, A_0=8720; r^2=0.15 and RSS=10.2)

Although with a low regression coefficient, r^2=0.02, food poverty incidence positively correlated with family size High income households showed more food poverty incidence than low income households on account of the large family size (Figure 3a). Cultural attitude of extended family relations and dependency were some major factors contributing to large family sizes especially of high income earning households. Equally, poverty was more prevalent among households whose heads had a low level of education and working in the public sector (85.8%). By contrast poverty incidence among households whose heads had university education and working in the private sector stood at 14.2%.

For the four localities, the poverty incidence indicated that about 94% of all those households in the studied area were under the poverty line. However, it is thought that the income levels acquired through the filed survey were of low reliability as, it was noticed that, most of the residents tended to state their income levels lower than actual ones. Such high levels of poverty, according to individual household poverty line, could be attributed to the large family sizes (Figure 3b), high market prices with stagnating monthly incomes. Monthly expenditures for all localities showed that most households spent two-thirds or more of their incomes to meet their food needs, one-third on other demands like school fees, health care, transport and loan repayments. The poverty depth and gradations relative to the poverty line among the different localities of the studied area were extensive.

Figure 3b shows that although with low regression coefficient r^2=0.17, the household monthly income positively correlated with the food poverty index. This implied that increased monthly income resulted in significant increase in food poverty index in most households. This ironically, may be described as "*high income poverty*" where even middle-income households were still below the food poverty line. Although until 2010 there was still no official classification of incomes levels in S. Sudan, monthly incomes between 350-1,000SDG could be termed as low, between 1000-2500 as middle and over 3000 SDG as high. Other than the already high non-food expenditures (*health care, school fees, transport, etc.*) for most households, some other factors like large family size necessitated by rural-urban migration of extended family members resulting into dependency, significantly led to reduction in the per capita food expenditure (Figure 3b).

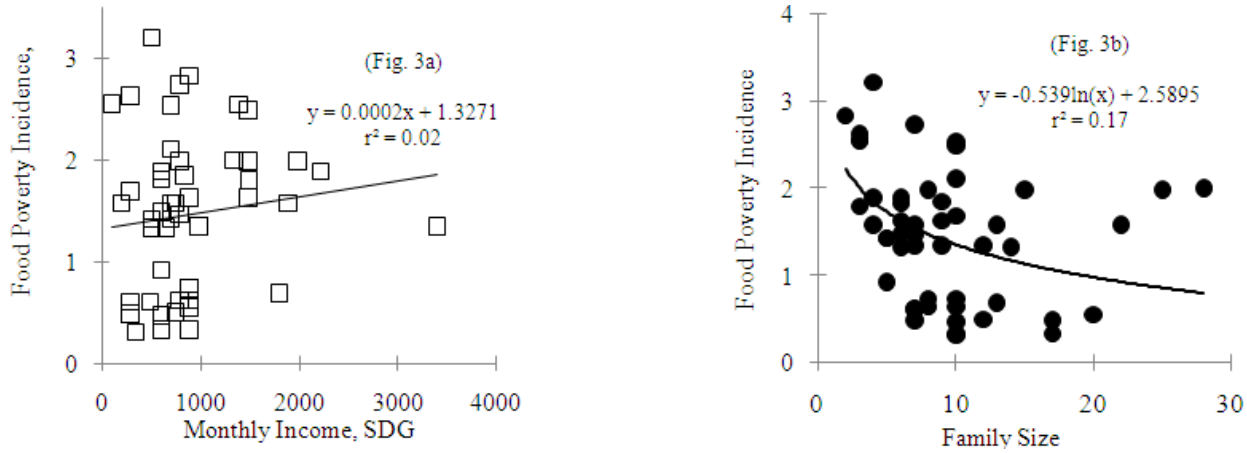

Figure 3. The relationship between the monthly income and (a) household food poverty incidence, FPI and (b) per capita food consumption for households in four localities of Juba Town

Some selected professions in Figure 4 showed that more than 92% of all individual households were below the poverty line except for few households in Kator and Munuki. These were exceptions and did not reflect the general trend of high poverty incidences and poverty depths. Juba na Bari and Gudele showed extreme poverty. Although households in Juba na Bari had comparatively higher monthly incomes, this was leveled out by high expenditures attributable to high living costs. This suggested that the larger the family size, the greater the poverty rate (80-95%), poverty vulnerability and risks and the greater was the depth poverty as illustrated in Figure 3b.

From the point of view of per capita food expenditure per household, there was no significant difference between the well and low paid professions. The engineer resident in Kator for example had a gross monthly wage of 2,000 SDG with six members whereas the cleaner had monthly wage of did not vary. Conversely, the business-woman, had a net profit gain of 400 SDG monthly, which atyear´s end amounted to about 4,800 SDG given the average monthly income of about 1,500 SDG with a moderate expenditure and small family size of about 6 persons as in Figure 5. The household is therefore less vulnerable to food insecurity given the dailyper capita expenditure of about 8 SDG. About 60 SDG per day was spent on food apart from other expenses (*school fees, house rent, health care and treatment*). Both the businesswoman and the Director General had an annual net surplus cash of 3,600

and 4,800 SDG respectively whereas the army officer and the driver had an annual net debt of 3,600 and 6,000 SDG respectively. This high net annual deficit for most households in Juba na Bari exposes them to serious food insecurity risks. The reasons are the low monthly incomes and large family sizes that have to be sustained, thus compelling the household heads to go for credit or loans.

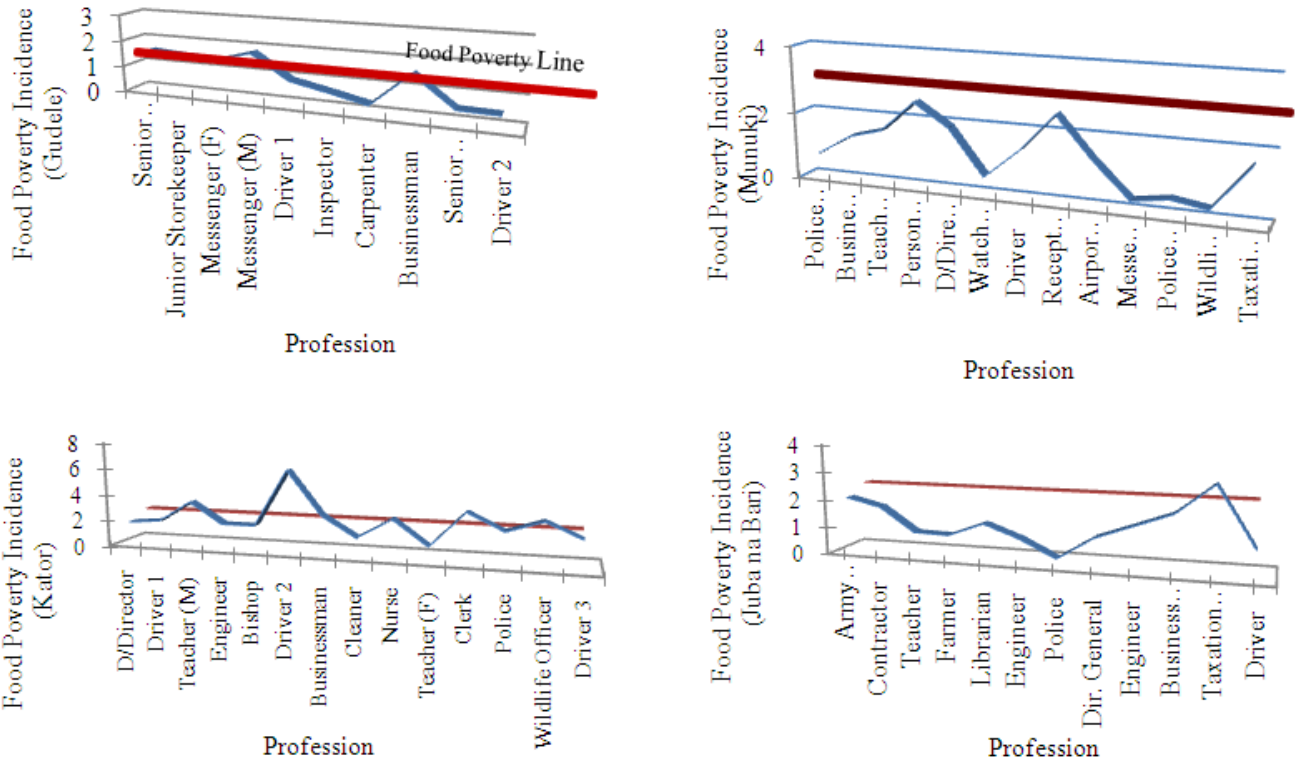

Figure 4. The relationship between the different professions and poverty incidence of some selected households in four localities of Juba Town

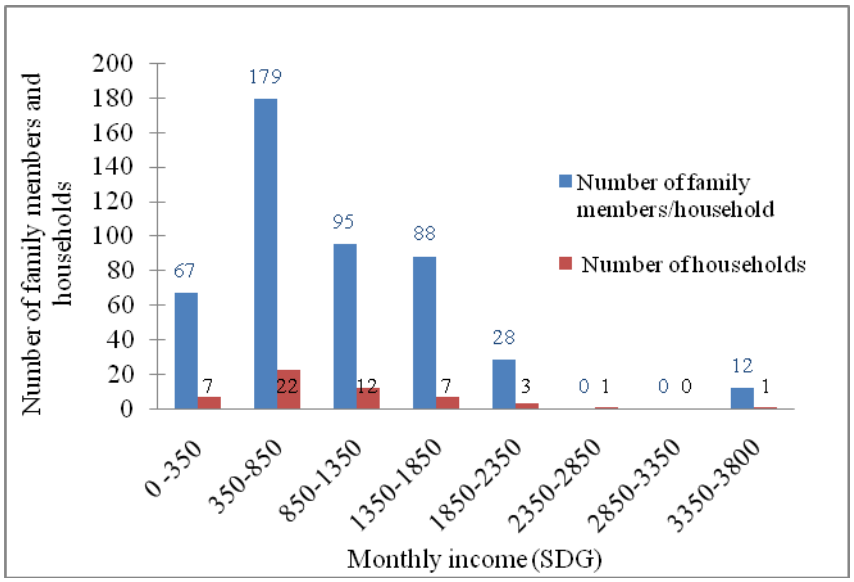

Figure 5. The distribution of monthly income as a function of the family sizes and number of households in four localities of Juba Town

A cluster sampling of households that is representative of the populations of the different residential areas of Juba Town was selected. Clustering the number of households and family sizes in terms of monthly incomes showed that the highest group was 34 families with monthly incomes of 350-1350 SDG/month representing 64.1% of all households with 274 family members followed by 14 families with incomes between less than 350 and 1350-1850 SDG/month representing 26.4% of all households and with 155 family members. The lowest groups were those with incomes over 1850 SDG representing the rest with 40 family members.

3.1. Income Distribution Inequality

The Gini coefficient was used as a measure of the degree of inequality among the total population of the four localities. The coefficient sets that 0 corresponds with perfect equality *(where everyone has the same income*) and 1 corresponds with perfect inequality (*where one person has all the income—and everyone else has zero*

income).The Gini coefficient of 0.32 in Figure 6 showed that half of the population in the four localities had a total income of about 32%. The first coefficient of the polynomial function of the Lorenz curve gives an approximation of the Gini coefficient as 0.37. This is perceived as high inequality and comparable to those values reported by [22].

Accordingly, the Gini coefficient of 0.32 (Figure 6) for the study area clustered inequality irrespective of profession, monthly income, sector and even gender, The coefficient did not delineate poverty gaps between the different households just above and below the poverty line. Implications for households clustered slightly above the poverty line are that, they could easily slip below the poverty line, if there were increase in family sizes, severe inflation and economic crisis, stagnating incomes, while those below the poverty line would experience a further increase in the poverty gap.

The study here found out that income inequality among the different professions was—high in the public sector but low in the private sector. Similarly, gender-based income inequality was high among women (only 30% employment in the public sector with low pay not exceeding 500 SDG/month and 4% in private sector) than men in both private and public sectors — making women the poorest in all households. The high income inequality of women is associated with the poor education background and lack of useable skills that would suit them into well paid jobs in either private or public sectors. Measured at the household level, the monthly income of most households ranged between 350-1000 SDG for Gudele, Kator, and Munuki while this was between 1530-3000 SDG for Juba na Bari. With respect to the nature of professions of the different household heads, the monthly incomes varied with sector and gender. Public sector employment was 62% for most household heads while this was 38% in the private sector. Gender disparity was significant between male- and female-dominated jobs. For example, male-dominated jobs accounted for 69% of all jobs double so much than for female-dominated jobs at 31%.

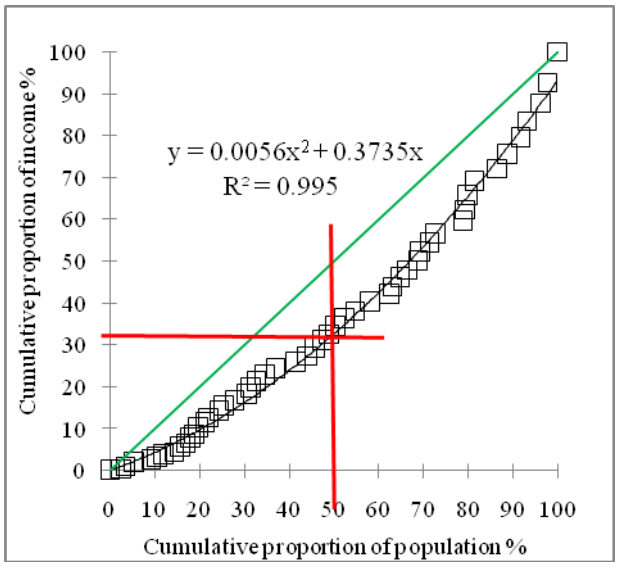

Figure 6. The Lorenz curve showing position of the Gini coefficient for households in four localities of Juba Town

Over 94% of female employees in the public sector had incomes not exceeding 750 SDG/month, suggesting a high share of women living in severe food shortage and below the food poverty line. Such female-led households consumed meat once per week. Figure 7 shows that about 78% of the households in the four localities had gross monthly incomes between SDG 910-1,372 with about 10% between SDG 1,528-2,142 and about 12% below SDG 756. Kator and Gudele localities had the lowest gross monthly incomes on average at between SDG 448-1,218 while Juba na Bari and Munukiwere on average between SDG 1,528-2,450.

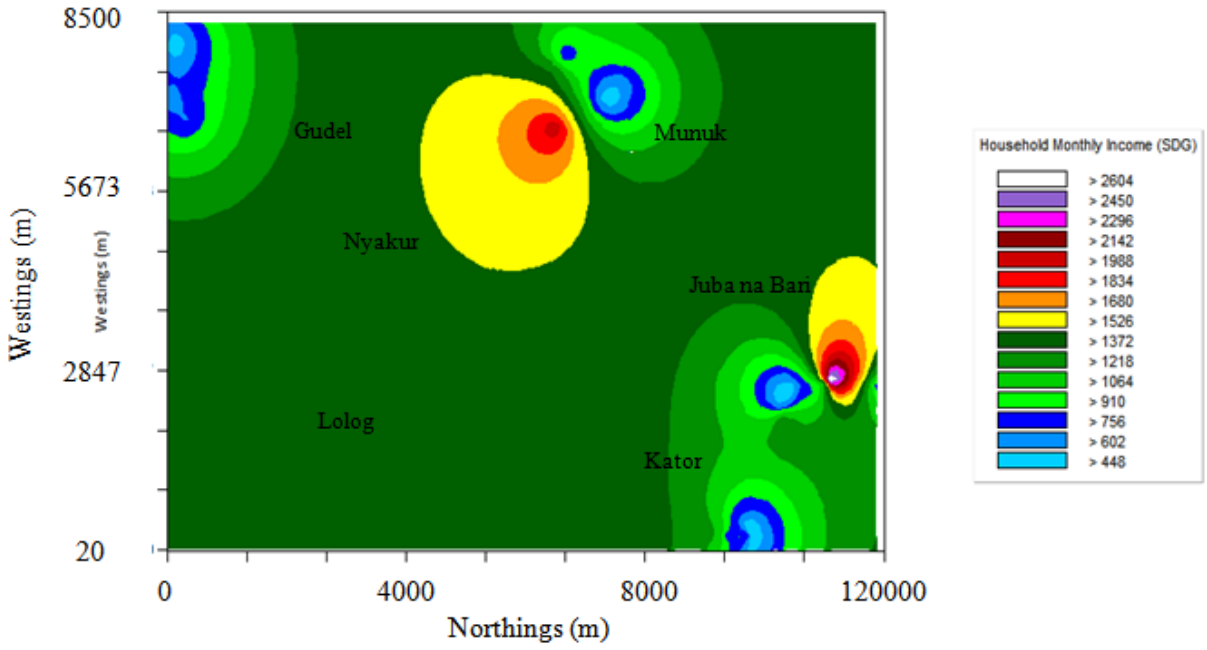

Figure 7. The spatial distribution of monthly incomes of households in four localities of Juba Town

After several simulations, the Gaussian isotropic model gave the best fit, though with low r^2=0.02 (Figure 8). It can be stated that, for the Gaussian model, the nugget variance (C_0) revealed continuity and spatial dependence

for distances shorter or equal to the range A_0, while this showed discontinuity for nugget variances greater than the range. Spatial analysis of the monthly incomes using isotropic variogram showed that the income distribution of the different households in the four localities had significant spatial dependency (S=36.5% where S=nugget/sill). This can be described as "*moderate dependency*" according to [21]. Monthly incomes of all households observed in distances less than the range A_0at 1144 m showed some spatial dependency [23] suggesting that, data collection of monthly incomes was more or less uniform and relevant at 1144 m separation distances.

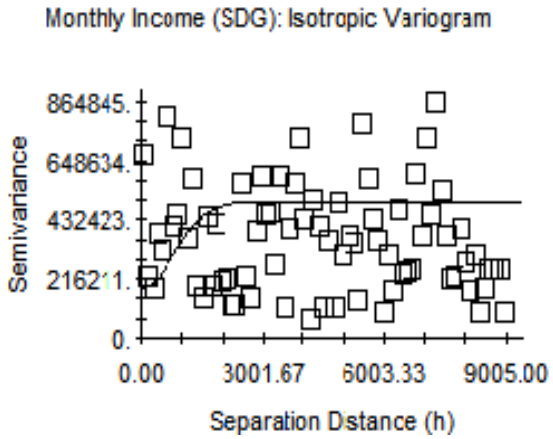

Figure 8. Isotropic variogram for the spatial distribution of monthly incomes of different households in in 4 localities of Juba Town. (Nugget, C_0=182482.35; Sill, C_0+C=500399.46; Range, A_0=1144.09; r^2=0.02 and RSS=4.47E+12)

3.2. Minimum Subsistence Level

The minimum subsistence level of households in the study area were assessed based on food norm. This norm set the minimum amount of food items contained in a basket within a given time that was affordable and nutritionally healthy. Such included a wide range of foods rich in animal protein (meat, eggs, fish, milk etc.), plant protein (beans, peas, lentils etc.) fresh fruits and vegetables. The subsistence food basket for the studied households predominantly focused on animal proteins (beef meat) and plant vitamins (vegetables and fruits). The normative food basket for most households(Kator, Gudele and Juba na Bari) ranged between 430 to 570 SDG/month. Meat consumption positively correlated with increased monthly income but negatively correlated with vegetable consumption except for Munuki (Figure 9). Most households with monthly incomes between 300-1000 SDG spent between 47-86% of their incomes on food while this was between 30-43% for households with monthly incomes between 1000-4000 SDG. The per capita food norm amount in a 22-member household was about 82 SDG/month, while this was about 150 SDG/month for a 2-member household. The former consumed less meat 1-2 days/week and more vegetable while the latter had larger per capita food expenditure and consumed meat 3-4 days/week. Fur Munuki, a combination of proteins derived from meat as well vitamins obtained from the vegetables may not necessarily have met the basic requirements for food needs of between 1,885 and 2,500 kilocalories as reported by [17,24].

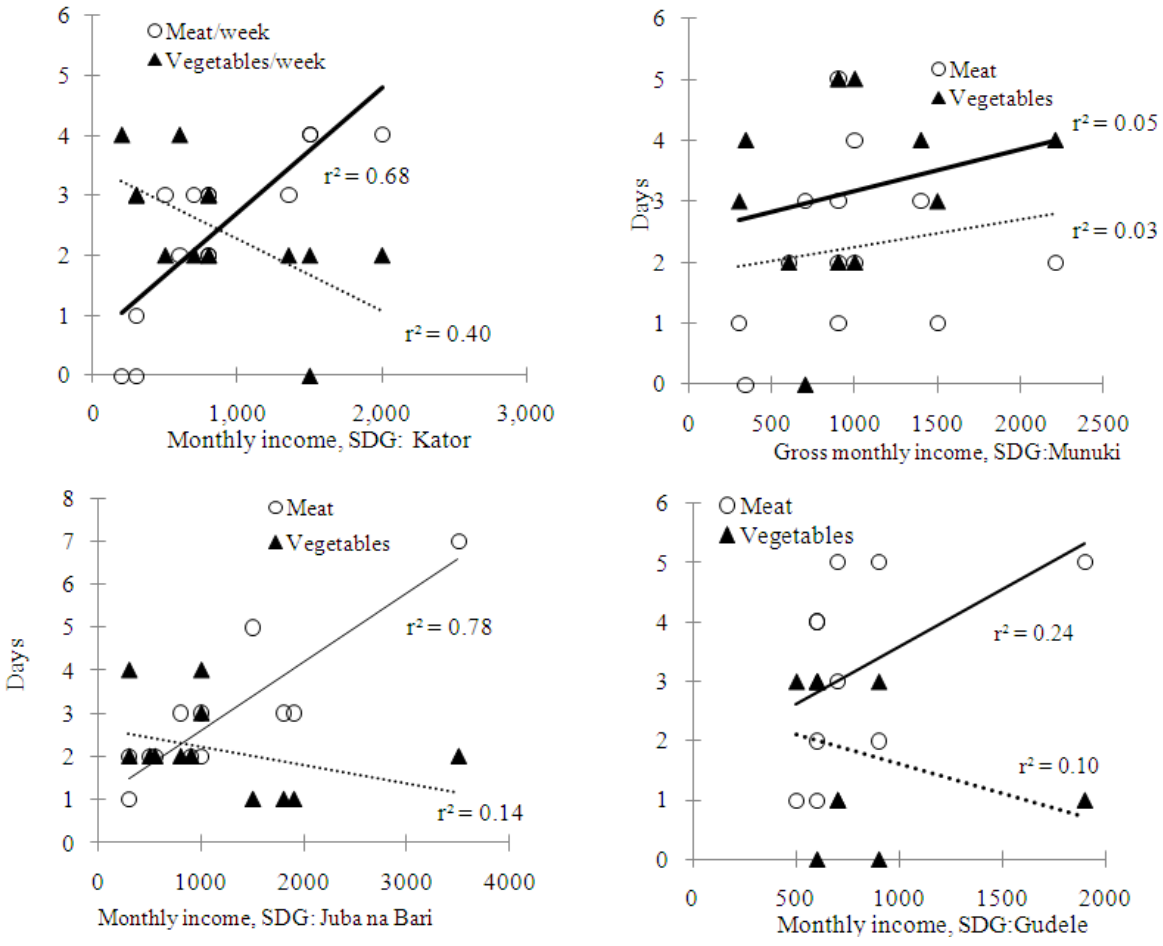

Figure 9. The relationship between monthly income and number of days per week for meat and vegetable consumption in different households of Juba Town

Meat consumption for the four localities was on average 3-4/week and correlated positively (between r^2=0.1 and r^2=0.78) with increase in monthly incomes. Socio-culturally, increased meat consumption in a household is indicative of affordability for mostly income-stable families which showed less preference for vegetables and fruits. Similarly, vegetable consumption was 1-3 days/week and negatively correlated (between r^2 = 0.03 and r^2=0.4) with monthly incomes of the various professional groups. However, increased animal protein consumption with less vegetable, fruit or salads (Figure 9) does also suggest poor dietary compositions of low caloric value.

Less preference for fruits and salads as part of diet is shown by the poor correlation (Juba na Bari r^2=0.14; Kator r^2= 0.40; Gudele r^2=0.1 and Munuki r^2= 0.03 irrespective of increased monthly incomes. Unconfirmed medical reports in Juba suggest a high rate of gout disease among the population as a result of increased consumption of cow *liver, heart, kidneys, small intestines (locally known as marara, kuminia*). Gout is caused due to accumulation of intermediate and final products of protein biosynthesis like monosodium urate crystals (*a type of uric acid*) in the body causing pain around joints. [25,26,27,28] found out that increased consumption of purin-rich beef, lamb meat, organ meat increased risk gout and especially among men. The results here indicate a rise in protein consumption with a corresponding decline in consumption of vitamin-rich fruits, vegetables and salads.

Since estimating the daily per capita calorie consumption of the different households was beyond the scope of this study, general observations were placed on the nutritional and dietary inadequacies of the foods consumed. The ability for food use that would ensure a balanced diet and meeting the 2,100 daily per capita calorie benchmark through the consumption of carbohydrates, proteins and fats was missed by all households irrespective of income levels.

3.3. Availability, Accessability, Affordability and Usability of Food

Food consumption in space and time is invariably influenced by a whole range of factors including availability, accessibility [29] which conversely is affected by disposable income (affordability) [30,31] socio-economic status) as well as traditional and cultural norms. [32].

The essence of formulating any food security policies in South Sudan would have to ensure that, food is not only accessible and affordable but also usable in terms of requirements for healthy living. However, the absence of data on daily nutrient requirements of greater part of the population of South Sudan is one major problem in estimating the Recommended Dietary Allowance (RDA). Such would also require setting benchmarks for minimum basic needs. A better estimate would be the cost of basic needs (CBN) approach that anchors food consumption bundle to calorie requirement as suggested by [33].

3.3.1. Food Availability

After 21 years of a bitter civil war and subsequent signing of the Comprehensive Peace Agreement (CPA) in 2005, South Sudan still imports about 60-70%[1] of its food from Uganda, Kenya and Sudan to feed its population. Despite sound agricultural policies on food security, South Sudan has not yet attained self-sufficiency enough to meet the increasing demands of an ever increasing population. Food availability in Juba is still much dependent on the economic imperatives as well as climatic and production conditions prevailing within these countries. For example, in November 2010 witnessed serious food shortages in Juba due to over-flooded and impassable roads in northern Uganda. Such seasonal variations influence dietary diversity and hence amount of calories consumed per day per capita. Similar trends of seasonal variations of nutritional status of women in Burkina Faso were also reported by [34].

3.3.2. Food Accessibility

The persistent food shortages especially in Juba despite surplus food production between 2009-2010 in the surrounding counties of Magwi in Eastern Equatoria and Yei River in Central Equatoria indicates a systematic failure in distribution of food (*maize, sesame, sorghum, cassava and fresh vegetables*) and inability of larger part of the population to access enough food. Poor road infra-structure to production sites coupled with sluggish bureaucracy and corruption, ensured that most food did not get to local markets in time. Rather, much was diverted to markets in northern Uganda or led to rotting and wastage.

3.3.3. Food Usability

The daily per capita range of calorific values was estimated on the basis of a combination of foods consumed daily and affordable by the different households. Low to middle income households had one or at most 2 meals daily with calorie intake between 500 to 2,500 Kcal on average, whereas this was between 1,000 to 3,500 Kcal for middle to high income households with between 2 to 3 meals daily. Such low calorie intake for low income households may pose serious health risks for especially young growing children. High rates of stunting and underweight prevalence as a result of food insecurity among children have been reported in Bangladesh, Ethiopia and Vietnam [35,36] or a result of reduced dietary diversity among children [37]. In the US, social welfare recipients especially among black and white women with low income showed poor physical and mental health [38] or poor school performance or [39,40] behavioral problems [41,42] or overweight [43] among school children. Similarly, nutrition related risk of overweight in women, some girls and children was reported by [44,45].

Table 3 shows the daily per capita calorific values of some foods consumed in the studied localities of Juba Town. The calorific values were not empirically validated but simply compared and aligned to those estimated at[www.calorieking.com/foods]. The daily calorie intake was estimated by combining the different foods consumed during different times of the day as a function of food expenditure. Low income households had less per capita food expenditure and could only afford between 0 to 1 meal per day, middle income households between 1 to 2 whereas high income households between 2 to 3 meals/day. The whole range of possible calorie intake per

[1]Interview with Dr. David Lomeling conducted in March 2011 by Nyambura Wambugu. Horn of Africa Bulletin, June-July 2011

capita per day for an adolescent is illustrated in Figure 100000000.

Table 3.The daily mean per capita food consumption in terms of estimated calorie intake for an average adolescent in Juba Town

Meal Time	Type of Food	Local name	Intake in (g) or (ml)	Estimated Calorific Value	Total Estimated Calorific Value (adult male)
Breakfast (B)	I) 2 pcs of wheat bread; or II) 4 pieces of fried crumpets; with 1 cup of black tea + milk+sugar	*Eish* *Legemat*	180 160 5	478 576 42	1096
Lunch (L)	I) Kidney beans stewed with tomato paste served with mixed cassava-maize flour meal	*Janjaro* *Ilong/Ugali*	250 80 350	340 14 260	614
	II) Lentils stewed with tomato paste served with mixed maize-cassava flour meal	*Adas* *Ilong/Ugali*	250 80 350	370 14 260	644
	III) Chicken piece stewed with tomato paste served with mixed maize-cassava flour meal	*Sukurikelo* *Ilong/Ugali*	250 80 350	583 14 260	857
	IV) Fully cooked beef served with mixed maize-cassava flour meal	*Lokore lo kiteng* *Ilong/Ugali*	350 350	380 260	654
	V) Cowpea seeds cooked with peanut butter and served with mixed maize-cassava flour meal	*Burukucu* *Ilong or Ugali*	250 150 350	340 878 260	1478
	VI) Kale fully cooked served with mixed maize-cassava flour meal	*Sukuma wiki* *Ilong/Ugali*	300 350	84 260	564
	VII) Green leaves of cowpeas pasted with peanut butter served with mixed maize-cassava flour meal	*Ngete/Koropo* *Ilong/Ugali*	250 150 350	187 878 260	1325
	VIII) Dry salted Mudfish pasted with peanut butter served with mixed maize-cassava flour meal	*Tora-jujuk* *Ilong or Kisra*	250 150 350	470 878 260	1608
	VIX) Dry ground beef meat (85% lean, 15% fat) pasted with tomatoes served with maize-cassava mix flour meal	*Tegelia* *Ilong or Kisra*	250 80 350	538 199 14 260	1011
	X) Tilapia stewed pasted with tomatoes served with mixed maize-cassava flour	*Regong* *Ilong or Kisra*	250 80 350	410 14 260	684
	XI) Green leaves of *Amaranthus* stewed with tomato paste served with maize-flour meal	*Kwedekwede* *Ilong/Ugali*	250 80 350	210 14 260	704
	XII) Beef liver pan fried served with 2 pieces of wheat bread	*Munyetkelo*	250 180	438 478	916
Dinner (D)	I) Broad beans (Fava) boiled with 5 spoonful of sesame oil, Fresh red tomatoes, 1 large egg, Cheese Served with 2 pieces wheat bread		250 80 80 180	275 199 14 78 126 478	1170
	II) BBQ Beef grilled and salted Green salads (*1cucumber with sesame oil dressing*) Tomatoes Onions (1 small piece) Served with 2 pieces of wheat bread	*Lokorepelo*	250 80 50 180	357 140 14 21 478	1010
Juices, (J and B) Beverages and Beers	I) Mango Nectar Juice		300 ml	148	436
	II) 1 bottle of Cola		300 ml	111	
	III) 1 bottle of Heinecken Beer (5%)		750 ml	177	

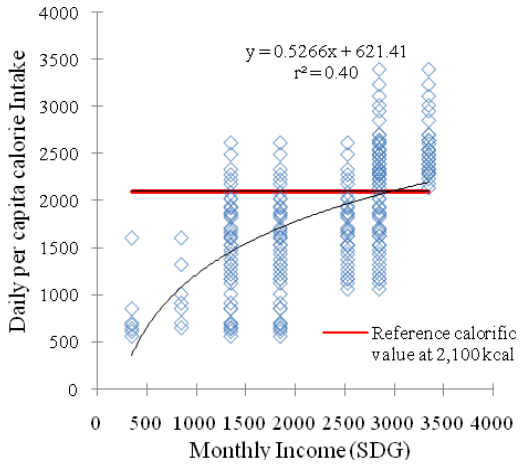

Figure 10. Estimated daily per capita calorie intake of an adolescent in the four localities of Juba Town as a function of monthly income

Energy intake assessed from consumption data indicated a logarithmic increase in the daily per capita calorie intake in all four localities of Juba Town as a function of monthly income. Households with monthly incomes less than 500 SDG had less than 1000 kcal/day this is about half less than the standard threshold value implying serious energy deficit and therefore undernourishment. Despite moderate incomes between 1500-3000 SDG/month, the per capita calorie intake was still largely below the threshold value. This is partly due to the large family sizes with reduced per capita food expenditure. Households with incomes above 3500 SDG/month had daily per capita calorie intake above the threshold value. Between 65-80% of all households had

daily per capita calorie intake below the threshold value of 2,100Kcal (Figure 100000000). Undoubtedly, the responsiveness of daily calorie intake per capita as a function of monthly income is subject to change especially during economic shock periods of price increase and inflation. Therefore, even high income households (*over 3400 SDG/month*) risk backsliding into food insecurity below the threshold level. Similar drop in consumer spending on high-value foods was also reported in Indonesia by [46,47,48]. In the study, we found out that the per capita calorific intake of consumers was independent of type of food consumed (Table 2) but with increasing purchasing power, most high income households made more broader dietary diversification choices from predominantly vegetarian toward more micronutrient-rich, taste-preferred foods like meat, sodas fish etc. [49]. Admittedly, a better assessment of food poverty incidence at household level would be the dietary diversity indicator as opposed to the daily calorie intake. After all, low income households at around 1,500 SDG/month had more or less similar daily calorific values as those with monthly incomes at about 3,000 SDG.

Source: Most foods were compared to those at www.calorieking.com/foods

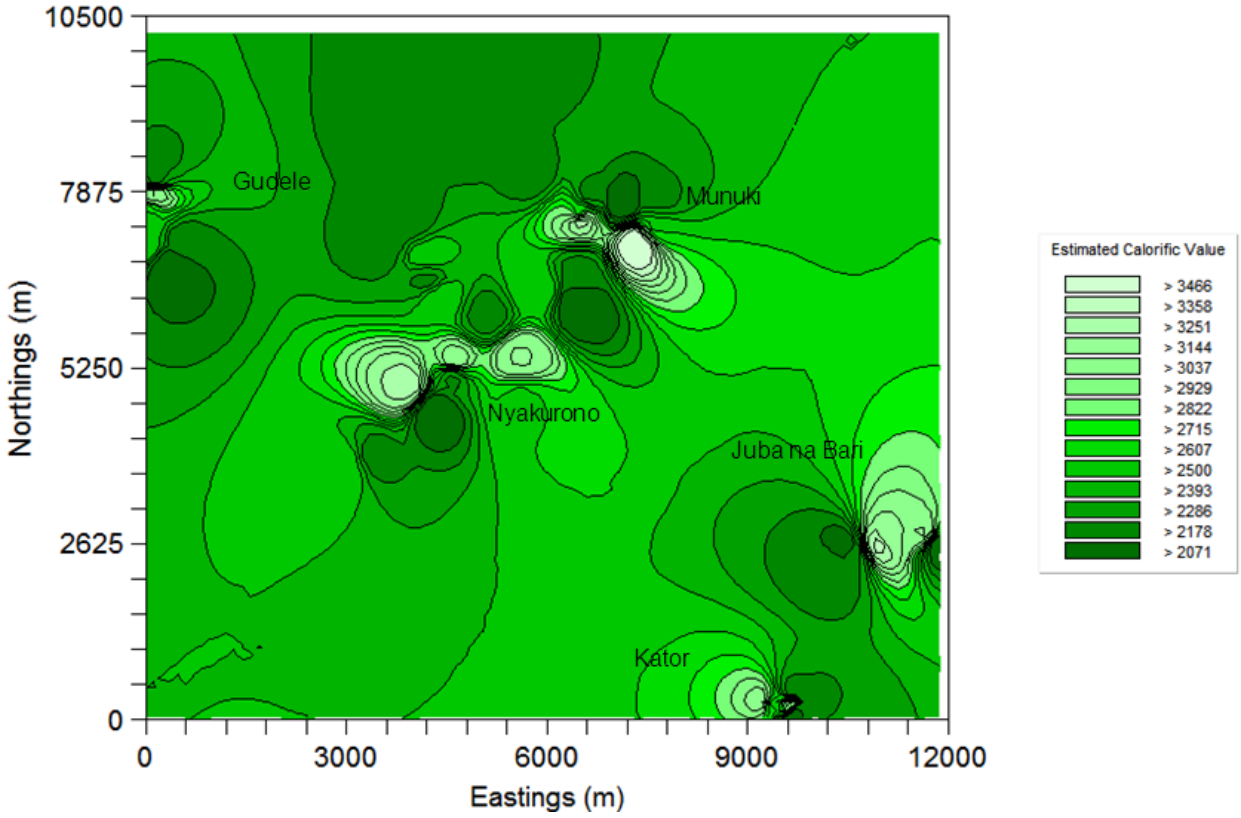

Figure 11. Spatial distribution of the estimated per capita calorific values consumed daily within the different localities of Juba Town

No significant differences in the daily energy intake between predominantly meat- and vegetable-consuming households were observed. Low income households (350-850 SDG/month) in all four localities predominantly consumed vegetables and had either single meal with relatively lower proportion of daily energy intake between 975-1,874 Kcal while middle-income households had daily energy intake between 2,700 to 3,040 kcal. High income households whereas, had daily energy intake of over 3,400 Kcal (Figure 111111111). The high calorific value of vegetable dishes is attributable to cooking methods that often used oil-rich pasted peanut butter. On average however, the daily energy intake of all four localities varied between 2,500 and 3,000 Kcal independent of food preference and income. Anchoring calorific values to poverty as suggested by [50] and [51,52] may in this case be inappropriate. Often, there is either a weak or no correlation between calorie deprivation and anthropometric indicators as reported in similar studies of malnutrition in India [53] and Ethiopia [54]. Two major features may be inferred; firstly, the daily capita calorie intake relative to the internationally accepted value inadequately prescribes the per capita or household welfare state especially as in the case for the localities in of Juba Town. Secondly, socio-economic conditioned consumption patterns as witnessed by varied household incomes influence food preference thereby providing a wide range of choices that may lead to different calorie intake.

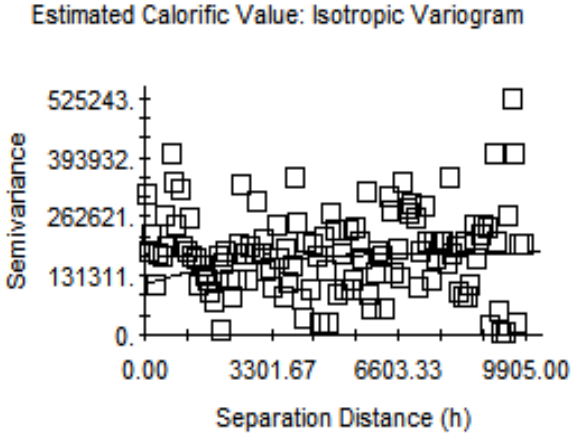

Figure 12. Isotropic variogram for the spatial distribution of estimated daily calorific value per capita in the four localities of Juba Town. (Nugget, C_0=110826.1675; Sill, C_0+C=183900.00; Range, A_0=2313.11; r^2=0.01 and RSS=1.15E+12)

The exponential model gave the best fit, though with low r^2=0.01 (Figure 122222222). Spatial analysis using isotropic variogram showed that the estimated daily per capita calorific values of adolescent among the different households in the four localities had significant spatialde pendency (S=60.3% where S=nugget/sill). This can be described as "*moderate dependency*" according to [21].

Estimated daily per capita calorific values of all households observed in distances less than the rangeA_0at 2313 m showed some spatial dependency suggesting that, data collection was more or less uniform and relevant within a 2.3 km separation distance.

Qualifying the extent and severity of food security and deprivation in the different households showed that about 13% of the households with incomes less than 500 SDG/month were severely food insecure with constant hunger corroborating similar findings reported by [9]. About 41.5% of the households with incomes between 350-800 SDG/month were food insecure with moderate hunger; 35.8% of the households with incomes between 850-1850 SDG/month were food insecure but without hunger; whereas 7.5% of the households with incomes between 1,850 and 4,000 SDG/month were food secure. This gradation of food deprivation in households may be conceived of, as a *continuum* of increasingly severe conditions and experiences which extends from fully secure at one point to a severe food insecurity level at another point. Experiential hunger was largely due to lack of resources to obtain food for the household. The difficulty in assessing a household´s or individual´s food insecurity status lies more on the quantification or putting up quantifiable indicators for each level of food security. In the South Sudanese context, there are neither standardized questionnaires nor set benchmarks for food security estimation at both household and individual level.

4. Conclusion

Food insecurity in the four localities of Juba Town is projected to remain a serious problem in the next 5 years as most households are unable to afford, access and utilize food for a healthy living. The ongoing current political instability has led to a large influx of displaced persons and refugees from other states into Juba Town, exacerbating the already severe food security situation.

The daily per capita calorie intake of large families of low income is projected to remain stagnant or drop below the 500 Kcal level, suggesting that food consumption for most households is expected to slip further below the nutritional set target. Furthermore, the per capita calorie intake for middle to high income households is projected to drop due to increasing food prices further increasing household food insecurity.

The paper set out to explore whether normative food poverty line that reflects the welfare state of a household may by implications, be anchored to daily per capita calorie requirements. We have shown through our paper, that independent of income, there were no significant differences in the per capita daily calorie intake. Low income households with less choice for dietary diversity could still have high daily calorie intake, if the method of food preparation especially for vegetable dishes uses predominantly oil-rich peanut butter.

Lack of standardized questionnaires that would form the basis for food security assessment and scaling of food deprivation levels of households further underpins the inability to objectively discriminate or explore the intra-household caloric needs based on gender, age or maturation stage.

The Government of South Sudan still operates as the single largest employer and accounts for 63% of all jobs in the public sector with about 69% of all jobs as male-dominated. Women are poorly represented in both public and private sectors with much concentration in the informal sector through retailing of farm produce and manufactured goods. Although limited and erratic in nature, this informal sector ensures livelihoods for thousands of households, significantly transforming the welfare and daily calorific intake of most households.

Given the high percentage of households below the food poverty line, subsequent research should focus more on what traditional dishes and food preparation methods would be adequate that are viable and ensure high nutritional status above set threshold limits for especially low income households. Of course, the estimated calorific values assessed herein did not capture the full complexity of foods consumed within the localities or in South Sudan at large, but for estimations that have both temporal and spatial features across Juba Town, this was indispensable. Our paper underscored the relevance and versatility of geo-statistical tool to extrapolate and assess the status of food security in households of greater Juba Town despite limited data source.

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Statement of Competing Interests

We the authors hereby declare that we have no competing interest.

List of Abbreviations

MSB - Minimum Subsistence Basket
HBS - Household Budget Survey
SDG – Sudanese Guinee
UNICEF – United Nations Childrens´ Educational Fund
FAO- Food and Agricultural Organisation
IFPRI - International Food Policy and Research Institute
IDPs - Internal Displaced Persons
RDA - Recommended Dietary Allowance
WFP – World Food Programme
MUAC – Mid-Upper Arm Circumference
GDP – Gross Domestic Product

FPI – Food Poverty Incidence
FPL – Food Poverty Line
IDW - Inverse Distance Weighting
CPA - Comprehensive Peace Agreement.

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