



ESTIMATING HOUSEHOLD FOOD BUDGET SHARES AND ENGEL'S FOOD COEFFICIENT IN A LEAN FOOD SUPPLY MONTH IN GHANA: A MICRO DATA ANALYSIS

Isaac , ADDAI

Department of Interdisciplinary Studies, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development

Faculty of Education and Communication Sciences,

Ghana

Email: iaddai@aamusted.edu.gh / ikegh5palpay@gmail.com

ABSTRACT

Using the 2017 Ghana Living Standards Survey Round Seven data, this study used the Working-Leser linear model on demographic and household specific variables to determine the lean food season month of July household food budget share, Engel food coefficient, marginal food budget share and food expenditure elasticity. The results demonstrate that a 10% increase in monthly household income decreases the share of the monthly household food budget by -0.0117 of a percentage point on average, and *ceteris paribus*, and the evidence shows that the underlying household July month Engel food curve is characterized by an inverse link between household monthly food budget share and the household monthly total income. The findings statistically established that food is a necessary commodity and the food demand elasticity assessment showed that a 10% increase in household spending would increase household monthly food needs by an average of 9.8%, and *ceteris paribus*.

Keywords: Ghana, Working-Leser model, Household, Food budget share, Engel food curve, July,

Citation of Article: Addai, I (2022). Estimating household food budget shares and Engel's food coefficient in a lean food supply month in Ghana: A micro data analysis, *African Journal of Social Issues*, 5(1): 15-27

Date Submitted: 03/06/2022 **Date Accepted:** 05/09/2022 **Date Published:** December, 2022

1.0 INTRODUCTION

Since independence in 1957, the Government of Ghana (GOG) has focused much attention on the need to produce and ensure affordable food so that Ghanaians do not expend so much of their incomes on food; which is a trait of a developing economy. To achieve this goal, many policies and interventions aimed at increasing the supply provision of food for household consumption is implemented through its agency, the Ministry of Food and Agriculture (MOFA). But the FAO (2021) identified conflict, climate variability and extremes and economic slowdowns and downturns as affecting affordable food demand in sub-Saharan Africa (SSA). The Covid-19 pandemic has affected the economies of numerous countries, including Ghana, resulting in a shock to household food budgets (Boero, Cafiero, Gheri, Kepple, Rosero Moncayo and Viviani, 2021). For instance, the Covid-19 pandemic has worsened SSA countries' effort in ensuring affordable household food as 282 million people representing 21.0 percent of the population in Africa are facing moderate to severe food insecurity (FAO, 2021). This has in recent times led to a growing activity in exploring techniques aimed at exploring how household could have access to food while at the same time reducing household food budget share in total household expenditure. Hence, with only few years left to achieve the AU Agenda (2063) goals policy to combat hunger in all its forms by ensuring affordable household food budget on the African continent by 2025, it is necessary to examine the allocation of Ghanaian household budgets to food needs, numerous years after the Engel seminal paper (Aykac, 2018) which empirically studied the association between German households' income and expenditure for food, at a time when the Covid-19 pandemic still lingers on.

There has been an increased awareness that more emphasis needs to be paid to this area and this study seeks to provide an empirical assessment in Ghana's lean food supply month of July household food budget share to find out the monthly Engel food coefficient, marginal food budget share and food expenditure elasticity in a lean food supply month and how it affects household food consumption in Ghana. The expectation is that the estimates will provide useful insights in various aspects of household food demand with policy implications based on the existing on-going Ghana's economic development drive, which have pushed households to increase their demand for food from the open market rather than from their gardens and farms. Surveys undertaken on food budget shares across all the seasons comprising the bumper-harvest season in Ghana may not provide reliable estimates as those conducted in lean-food supply season month of July, during which food becomes a very scarce commodity. Ascertaining the July monthly Engel food coefficient, marginal food budget share and food expenditure elasticity will then provide reliable estimates that will facilitate policy all year round in Ghana.

This study is distinctive in its highlighting on a lean-season July monthly food budget share analysis in Ghana and contributes also to the few existing studies (Setsoafia, Ma and Renwick, 2022; Akparibo, Aryeetey, Asamane, Osei-Kwasi, Ioannou, Infield Solar, Cormie, Pereko, Amagloh, Caton and Cecil 2021; Jaiyeola Ado and Bayat, 2020; Essilfie, Sebu, Annim and Asmah, 2020; Annim and Frempong, 2018; Ansah, Marfo and Donkoh, 2020; Omari,

Frempong and Arthur, 2018; Kc, Legwegoh, Therien, Fraser and Antwi-Agyei, 2017; Ecker and Fang, 2016; Frempong and Annim, 2017; Otsuka, 2015; Maxwell, 1999; Nin-Pratt and McBride, 2014; Nsabiman, 2021; Nsabimana, Bali Swain, Surry and Ngabitsinze, 2020; Fashogbon and Oni, 2013; Von Braun, De Haen and Blanken, 1991; Abdulai and Aubert, 2004; Coulombe and Wodon, 2012b; Deaton, 1997; Ecker and Fang, 2016; Ecker, 2018; Fabiosa, 2011; Maxwell, 1999; Nin-Pratt and McBride, 2014; Devereux and Maxwell, 2001) on households' food budget shares in developing economies.

The structure of the paper is specified. The next section deals with the materials and methods, followed by the results section. The penultimate section offers the discussion of the results and a final section provides a summary and conclusion.

2.0 MATERIALS AND METHODS

2.1 Description of Variables

Description of variables for the paper

Table I presents descriptions of the July food monthly demand variables in the paper.

Table I: Descriptions of Household Monthly Budget Share Variables

<i>Variables</i>	<i>Descriptions</i>
JE_i	Total household _i expenditure in the month of July in nominal cedis
JM_i	Total household _i expenditure on food and non-alcoholic in nominal cedis in the month of July
$JULlogync$	July monthly natural logarithm of JE_i in nominal cedis
$MHFD_i$	July monthly household _i food demand share in total monthly household _i expenditure
\bar{P}	$MHFD_i$ mean estimate
$JHHsize$	Household _i size in the month of July
$JHHAGEY$	Household _i head age in years in the month of July
$JHMastus$	Household _i head marital status in the month of July
$JULCloth$	Household _i total expenditure on clothing in the month of July
$JULTOTHlth$	Household _i total expenditure on health in the month of July
$JULEduc$	Household _i total expenditure on education in the month of July
$JULTRSP$	Household _i total expenditure on transportation in the month of July
$JULCOMS$	Household _i total expenditure on telephone, telefax and internet services in the month of July

Household income in household surveys in developing economies is proxy by total household expenditure as by Deaton (1997), Engel and Kneip (1996), Hasan and Mozumder

(2017) and Nsabimana *et al.*, (2020), hence, this paper used total Ghana July monthly household expenditure as a proxy for total July monthly household income.

2.2 Empirical Methodology

Some theoretical considerations that influence the monthly household food budget decisions in Ghana are examined to guide the empirical model estimated in this paper. These are some socioeconomic variables, which are characteristics of household (Ansah *et al.* 2020). Given the foregoing, household demographic and specific variables, which potentially influence monthly household food budget based on data availability, given the application in a Ghanaian context, can be expressed as follows:

Household income is a major determinant determined in the literature as impacting household food budget (Nsabimana *et al.*, 2020; Hasan and Mozumder, 2017; Deaton, 1997; Engel and Kneip 1996). The expectations are that as household income improves in the month of July, the household July household budget allocation to food will decrease and $\delta MHFD_i / \delta JE_i \text{Log} < 0$ *ceteris paribus*. In Africa, the age of household head is respected and has the greatest effect on household food budget (Ansah *et al.* 2020; Nsabimana *et al.*, 2020). The expectation is that $\delta MHFD_i / \delta JHHAGEY_i > 0$ *ceteris paribus* (Nsabimana *et al.* 2020). Household size in the literature (Ansah *et al.* 2020; Nsabimana *et al.*, 2020) is assumed to influence household food expenditure. Food spending by extended Ghanaian households is also expected to increase during the lean food supply month of July when food is expensive. Hence, the expectation is that, $\delta MHFD_i / \delta JHHsize_i > 0$, *ceteris paribus*. Household head marital status is not expected to increase the household food expenditure in the lean month of July, although Ghanaians place a greater importance to the marital status of a household and the anticipation of the study is $\delta MHFD_i / \delta HHMastusus_i < 0$. Although the month of July is a lean food supply season in Ghana and food prices are very costly, it is expected that household will not substitute their clothing, health, education and transport expenditures to increasing the monthly food budget share. Hence, the anticipation of the study is $\delta MHFD_i / \delta JULcloth_i < 0$, $\delta MHFD_i / \delta JULTOThlth_i < 0$, $\delta MHFD_i / \delta JULEduc_i < 0$, $\delta MHFD_i / \delta JULTRSP_i < 0$.

2.3 Estimation Design

The paper defines the rate of household total food consumption expenditure in July to the total monthly expenditure as JM_i , and defines the rate of its nominal total expenditure in July as JE_i . It then quantified the household month of July food budget share which is used as the dependent variable as:

The paper defines the rate of household_i total food consumption expenditure in July to the total monthly expenditure as JM_i . It then quantified the household month of July food budget share, $MHFD_i$ which is used as the dependent variable as:

$$MHFD_i = \frac{JM_i}{JE_i}$$

Mean regression based on the Working-Leser (1943, 1963) model of the form

$$MHFD_i = \alpha_0 + \beta_{\square 1}JULlogync_i + \beta_{\square 2}HHsize_i + \beta_{\square 3}HHMastus_i + \beta_{\square 4}HHAGEY_i + \beta_{\square 5}JULCloth_i + \beta_{\square 6}JULTOTHlth_i + \beta_{\square 7}JULEduc_i + \beta_{\square 8}JULTRSP_i + \beta_{\square 9}JULCOMS_i + \mu_{\square i}$$

is used to estimate the monthly Engel food coefficient, marginal food budget share, and food expenditure elasticity during the month of July in Ghana. $\mu_{\square i}$ is the stochastic disturbance term of the model normally distributed with a zero mean, and a constant variance, and $\beta_{\square 1} \dots, \beta_{\square 9}$ are parameters to be estimated and $i = 1, \dots, 1,374$.

We test the validity of the Engels food law in the month of July in Ghana as follows:

$$H_0: \hat{\beta}_{1\omega} = 0. \tag{1}$$

The household; July monthly marginal food budget share computed at the sampled mean value is calculated as:

$$\hat{\beta}_{1\omega} + \bar{P}, \text{ and } ceteris\ paribus \tag{2}$$

The household; July monthly food expenditure elasticity is computed at the sampled mean as:

$$\frac{\hat{\beta}_{1\omega}}{\bar{P}} + 1, \text{ and } ceteris\ paribus \tag{3}$$

$\hat{\beta}_{1\omega}$ is an estimated mean Engel food coefficient, and *ceteris paribus*.

Household income in household surveys in developing economies is proxy by total household expenditure as by Deaton (1997), Engel and Kneip (1996), Hasan and Mozumder, (2017) and Nsabimana *et al.* (2021), hence, this study used total July monthly household expenditure as a substitute for total July monthly household income. Cross section, living standards survey data in developing countries produced are characterized by a potential heteroscedasticity due to challenges in recollecting retrospectively and the fading of some respondents' memories, and the misinterpretation of a survey item among others (Grosh and Glewwe 1998). In adjusting for a potential heteroscedasticity in the Working-Leser (1943, 1968)

linear regression model, White (1980) specification of dealing with heteroscedasticity, using STATA robust option was applied to deal with it.

2.4 Data Source

Data used in this paper with permission is the 2017 Ghana Living Standards Survey VII belonging to the Ghana Statistics Office (GLSS). GLSS VII is the latest round of the National Household Survey conducted over a 12-month data collection period (22nd October, 2016 to 17th October, 2017). The data is diverse across the country and is endowed with household information in Ghana. The conduct of the survey received both national and international financial support as well as technical support from the World Bank. As such, the GLSS VII July monthly data is considered high quality and represents 1,374 households from all the regions in Ghana.

3.0 RESULTS

3.1 Descriptive Statistics of Variables

Table II: Descriptive Statistics of the Variables Used

Variable	Obs	Mean	Std. Dev.	Min	Max
MHFDi	1,374	0.541	0.184	0122	0.982
JULlogync	1,374	8.963	0.838	5.442	12.296
JHHsize	1,374	4.254	2.896	1	24
HHMastus	1,374	2.516	1.985	1	6
HHAGEY	1,374	45.720	15.652	19	99
JULCloth	1,374	716.830	914.415	0	10407
JULTOThlth	1,374	79.974	312.738	0	5500
JULEduc	1,374	1275.485	3674.536	0	106784.8
JULTRSP	1,374	1023.39	3076.353	0	69179
JULCOMS	1,374	281.746	403.815	0	3504

Source: Author's compilation from the GLSS VII Data.

Table II presents the means and standard deviations of both the demographic and household-specific variables used in the paper. It presents the household average July monthly food demand as a budget share and shows that household on average and *ceteris paribus* spend 54 Cedis out of every 100 Cedis on food in the month of July. The average age of household heads in the month of July is 45.7 years; average household size in the month of July was 4 persons and the average household expenditure on clothing was about 71.6 cedis, 83 pesewas. The average household monthly expenditure on health was 80 cedis, the average household expenditure on education was 127.5 cedis, the average household expenditure on transportation was 10.23 cedis and the average household expenditure on telephone, telefax and internet

services in the month of July was about 28.2 cedis. These selected variables have the potential of influencing household preferences on food budget share decisions in the month of July in Ghana. Household heads are assumed to have a leading control over the household resources and their budget allocations (Nsabimana *et al.* 2020).

3.2 Working-Leser OLS regression estimates

Table III: The Working-Leser Covariate Estimates

JULlogync	-0.0117*** (1.60)
JHHsize	-0.0018*** (-1.02)
JHHMastus	0.0019*** (0.80)
JHHAGEY	0.0015** (5.11)
JULCloth	-0.0001** (-5.08)
JULTOThlth	-0.0001* (-2.40)
JULEduc	-8.83e-06** (-6.57)
JULTRSP	-9.22e-06** (-5.58)
JULCOMS	-0.0004* (-3.15)
<i>N</i>	1,374

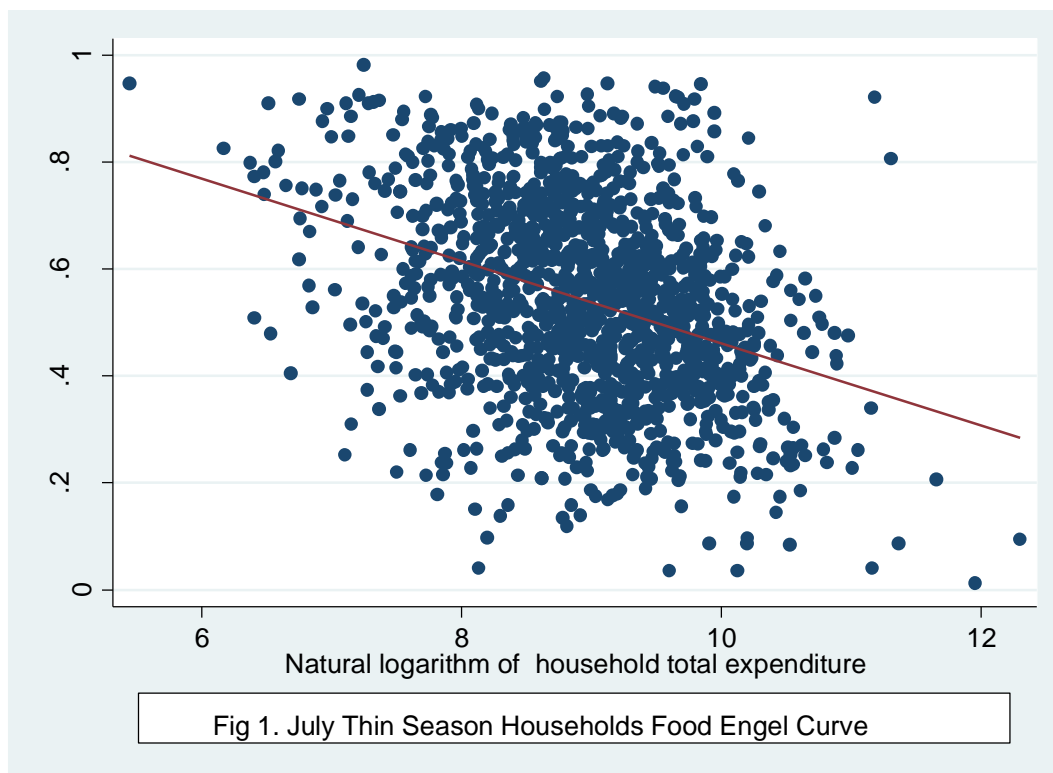
***, ** and * refers to the variables of which the estimated coefficients are statistically significant at level of 0.01, 0.05 and 0.1, respectively. t statistics in parentheses

Source: Author's compilation from the GLSS VII Data.

The Working-Leser (1943; 1963) model linear regression estimates are presented in Table III. It shows that demographic and household characteristics have impact on household budget allocation for food decisions. The estimated coefficient of household income and the marital status of the head of household have expected signs, but they are not significantly determined. The household size variable did not have the expected sign and was not significantly determined. These findings cannot be compared to observations made by Nsabimana *et al.* (2020) and Ansah *et al.* (2020) studies which examined all months and seasons of the year. Expenditures such as household clothing, household health, household education, household transportation and household communication in the thin food season in July all showed signs of

expectation and they were all significantly confirmed. The age of the head of household variable also showed sign of expectation and is significantly confirmed.

3.3 The July Thin Season Households' Food Engel Curve



The MHFDi variable is plotted along with the JULlogync estimates to ascertain the July thin season households Food Engel curve and is presented in Figure 1.

4.0 DISCUSSION

Examining the association between the MHFDi and the JULlogync variables in Fig I, evidence shows that the underlying household July month Engel food curve is characterized by an inverse link between household month of July food budget share and the natural log households July monthly total food expenditure and corresponds to Nsabimana *et al.*, (2020) results for Rwanda and Ansah *et al.*, (2020) results on Ghana. The estimated $\hat{\beta}_{1\omega}$ coefficient is the marginal response of the monthly household food budget share relative to the natural logarithm of monthly household total expenditure. It demonstrates that a 10% increase in monthly household expenditure decreases the share of the monthly household food budget by -0.0117 of a percentage point on average and *ceteris paribus*.

4.1 Testing the Validity of the Engels Food Law in the Month of July in Ghana

The study tests the validity of the Engels food law in the month of July in Ghana as follows:

$$H_0: \hat{\beta}_{1\omega} = 0$$

$$t_{1,364} = \frac{-0.0117 - 0}{0.0105 \text{ (S.E.)}} = -1.114 \quad [1.1']$$

The relevant critical value is -1.645 , hence the null hypothesis is rejected and the estimated $\hat{\beta}_{1\omega}$ effect is consistent with the Engel's food Law in the month of July, and *ceteris paribus*.

4.2 July Monthly Household Marginal Food Budget Share

The July monthly household marginal food budget share computed at the sample mean value is calculated as:

$$-0.0117 + 0.540937 = 0.529237 \quad [2.2']$$

Thus, a 1 cedi increase in monthly household expenditure in July would result in an average increase in monthly food expenditure of 53 pesewa in July, other things being equal.

4.3 The July Monthly Household Marginal Food Demand Elasticity

The July monthly household food demand elasticity is estimated as:

$$\varepsilon_{\omega} \frac{-0.0117}{0.540937} + 1 = 0.978 \quad [3.1']$$

The July monthly household food demand elasticity assessment shows that a 10% increase in household monthly spending in July would increase household monthly food needs by an average of 9.8%, *ceteris paribus*. The elasticity evaluate is numerically less than unity, and it posits that food is a necessary commodity in Ghana in the month of July.

4.4 Establishing Whether Food is a Necessity Commodity in Ghana in the Month of July

The paper used the sampling variance of JULlogync at the expenditure elasticity computed in [3.1'] to test the type of commodity food is categorized in Ghana in the month of July as follows:

$$H_0: \varepsilon_{\omega} = 1$$

$$H_a: \varepsilon_{\omega} < 1$$

$$\text{Var}(\hat{\varepsilon}_{\omega}) = \left(\frac{1}{P}\right)^2 \text{var}(\hat{\beta}_{\omega 1}) = \left(\frac{1}{0.5400937}\right)^2 \times 0.105354 = 0.36 \quad [4]$$

In this case, the null hypothesis is rejected suggesting that monthly household food demand for July is a necessary good in Ghana *ceteris paribus*.

5.0 SUMMARY AND CONCLUSION

This study examined the household food budget share design for the month of July lean food availability in Ghana based on GLSS7 data. It also assessed the household July monthly Engel food coefficient and curve relationships which are progressively gaining attention in household food budget share analysis in developing economies because of their clear link to intra and global food policy initiatives for national and global economic advancement analysis. The results elucidated the non-linear link between Ghanaian household food budget share and average household total expenditure. The findings provided further statistical proof that food is a necessary commodity in the lean month of July in Ghana and the household July monthly marginal food budget share is at a 53 percent (0.53 pesewas) and *ceteris paribus*.

This fact clearly places Ghana's economy in a food-insecure zone (Smith and Subandoro, 2007, Scrimshaw, 2008) making it difficult to achieve SDG target 2 (Addai, 2020). Policy-wise, this paper serves as an indicator in analysing household food budget share and demand designs in Ghana in the lean food-supply month of July. Economic improvement in Ghana means achieving food safety at all times in Ghana which calls for the country, Ghana, to double its effort in achieving the SDG Target 2.1 which has the aim of ending hunger and the SDG Target 2.2 which has as its goal the eradication of all types of malnutrition by the year 2030 and The African Union Agenda 2063 policy of The Accelerated Agricultural Growth Transformation Strategy (2014; 2015) which has as its objective to end hunger and food insecurity on the African continent by 2025 (Addai, 2020).

There is a very limiting basis for the study design as it did not deal with the household food demand for all the food seasons constituting the bumper harvest season in Ghana. However, there are some interesting strengths of this work such as identifying food as a necessity commodity in the month of July during which a 1 cedi increase in monthly household expenditure in July would bring about an average increase in monthly food expenditure of 53 pesewas, other things being equal. Further work is expected to include an extensive study of household food budget shares in Ghana during all food seasons and case studies by region.

REFERENCES

- Abdulai, A & Aubert, D (2004). A cross-section analysis of household demand for food and nutrients in Tanzania, *Agricultural Economics*, 31(1), 67–79. <https://doi.org/10.1111/j.1574-0862.2004.tb00222.x>
- Abdulai, A & Aubert, D (2004). Nonparametric and parametric analysis of calorie consumption in Tanzania, *Food Policy*, 29(2), 113–129. <https://doi.org/10.1016/j.foodpol.2004.02.002>
- Addai, I (2020). The Sustainable Development Goals and Ghana development nexus: An empirical assessment, *International Journal of Innovative Research and Development*, 9(7). <https://doi.org/10.24940/ijird/2020/v9/i7/jul20009>
- Addai, I (2020). Watching the watchman from Ghana: The case of agenda 2063. *Journal of Social Science Research*, 16, 41–46. <https://doi.org/10.24297/jssr.v16i.8762>
- African Union, 2013, “50th anniversary solemn declaration. *50th Anniversary Solemn Declaration*”, *AU Agenda 2063*. Available from: <https://au.int/en/documents/20130613/50th-anniversary-solemn-declaration-2013>, Accessed 1 Apr 2020.
- Annim, SK & Frempong, RB (2018). Effects of access to credit and income on dietary diversity in Ghana, *Food Security*, 10(6), 1649–1663. <https://doi.org/10.1007/s12571-018-0862-8>
- Aykac, G (2018). Testing the Engel law for Turkey and income elasticity of food demand: Relationship of budget share of food expenditure with household profile and total expenditure (2003-2013), *Sosyoekonomi*, 105–133. <https://doi.org/10.17233/sosyoekonomi.2018.04.07>
- Boero, V Cafiero, C Gheri, F Kepple, AW Rosero Moncayo, J and Viviani, S (2021). “Access to food in (2020): Results of twenty national surveys using the Food Insecurity Experience Scale”. Rome. FAO. <https://doi.org/10.4060/cb5623en>
- Coulombe, H and Wodon, Q (2012b). “A food insecurity map for Ghana.” In Q. Wodon (ed), *Improving the targeting of social programs in Ghana*, 50–58, Washington, DC: World Bank.
- Deaton, A (1997). *The analysis of household surveys: A micro-econometric approach to development policy*, World Bank Publications, Baltimore.
- Devereux, S & Maxwell, S (2001). Introduction: Food security in sub-Saharan africa. *Food Security in Sub-Saharan Africa*, 1–12. <https://doi.org/10.3362/9781780440170.001>
- Ecker, O (2018). Agricultural Transformation and Food and Nutrition Security in Ghana: Does farm production diversity (still) matter for household dietary diversity? *Food Policy*, 79, 271–282. <https://doi.org/10.1016/j.foodpol.2018.08.002>
- Engel, J & Kneip, A (1996). Recent approaches to estimating Engel Curves. *Journal of Economics*, 63(2), 187–212. <https://doi.org/10.1007/bf01258672>
- Essilfie, G Sebu, J Annim, SK & Asmah, EE (2020). Women's empowerment and household food security in Ghana, *International Journal of Social Economics*, 48(2), 279–296. <https://doi.org/10.1108/ijse-05-2020-0328>

- Fabiosa, JF (2011). Globalization and trends in world food consumption. *The Oxford handbook of the economics of food consumption and policy*, 590–611. <https://doi.org/10.1093/oxfordhb/9780199569441.013.0024>
- FAO, 2021, “Food and Agriculture Organization of the United Nations”. *Document card Food and Agriculture Organization of the United Nations*. Available from: <https://doi.org/10.4060/cb5623en> [accessed 16 Jan 2022].
- Fashogbon, AE & Oni, OA (2013). Heterogeneity in rural household food demand and its determinants in Ondo State, Nigeria: An application of quadratic almost ideal demand system, *Journal of Agricultural Science*, 5(2). <https://doi.org/10.5539/jas.v5n2p169>
- Frempong, RB & Annim, SK (2017). Dietary diversity and child malnutrition in Ghana, *Heliyon*, 3(5). <https://doi.org/10.1016/j.heliyon.2017.e00298>
- Ghana Statistical Service (2017). Ghana Living Standards Survey Round Seven, Main Report. Accra, Ghana.
- Grosh, ME & Glewwe, P (1998). Data Watch: The World Bank's living standards measurement study household surveys Margaret E. Grosh and Paul Glewwe. *Journal of Economic Perspectives*, 12(1), 187–196. <https://doi.org/10.1257/jep.12.1.187>
- Hasan, SA & Mozumder, P (2017). Income and energy use in Bangladesh: A household level analysis. *Energy Economics*, 65, 115–126. <https://doi.org/10.1016/j.eneco.2017.05.006>
- Jaiyeola, A Ado, G& Bayat, A (2020). Assessing the health, education, food and none food expenditure in Nigeria: Evidence from Engel Curve Analysis of household's expenditure in Nigeria. <https://doi.org/10.31124/advance.12971666.v1>
- KC, KB Legwegoh, AF Therien, A Fraser, EDG & Antwi-Agyei, P (2017). Food price, food security and dietary diversity: A comparative study of urban Cameroon and Ghana. *Journal of International Development*, 30(1), 42–60. <https://doi.org/10.1002/jid.3291>
- Leser, CE (1963). Forms of Engel functions. *Econometrica*, 31(4), 694. <https://doi.org/10.2307/1909167>
- Maxwell, D (1999). The political economy of urban food security in sub-Saharan Africa. *World Development*, 27(11), 1939–1953. [https://doi.org/10.1016/s0305-750x\(99\)00101-1](https://doi.org/10.1016/s0305-750x(99)00101-1)
- Nin-Pratt, A & McBride, L (2014). Agricultural intensification in Ghana: Evaluating the optimist's case for a green revolution. *Food Policy*, 48, 153–167. <https://doi.org/10.1016/j.foodpol.2014.05.004>
- Nsabimana, A (2021). Is change worth it? the effects of adopting modern agricultural inputs on household welfare in Rwanda. *African Journal of Agricultural and Resource Economics*, 16(3), 216–236. [https://doi.org/10.53936/afjare.2021.16\(3\).15](https://doi.org/10.53936/afjare.2021.16(3).15)
- Nsabimana, A Bali Swain, R Surry, Y & Ngabitsinze, JC (2020). Income and food Engel curves in Rwanda: A household microdata analysis. *Agricultural and Food Economics*, 8(1). <https://doi.org/10.1186/s40100-020-00154-4>

- Omari, R Frempong, GK & Arthur, W (2018). Public perceptions and worry about food safety hazards and risks in Ghana. *Food Control*, 93, 76–82. <https://doi.org/10.1016/j.foodcont.2018.05.026>
- Otsuka, K (2015). How promising is the Rice Green Revolution in Sub-Saharan Africa? Evidence from case studies in Mozambique, Tanzania, Uganda, and Ghana. *World Food Policy*, 2(1). <https://doi.org/10.18278/wfp.2.1.3>
- Scrimshaw, NS (2008). Book review: Measuring food security using household expenditure surveys, *Food and Nutrition Bulletin*, 29(2), 150–150. <https://doi.org/10.1177/156482650802900209>
- Smith, LC and Ali, S (2007). Measuring food security using household expenditure surveys. *Scribd*. Available from: <https://www.scribd.com/document/423748725/Measuring-Food-Security-Using-Household-Expenditure-Surveys-Smith-et-al> [Accessed 27 Feb 2020].
- Setsoafia, ED Ma, W & Renwick, A (2022). Effects of sustainable agricultural practices on farm income and food security in northern Ghana, *Agricultural and Food Economics*, 10(1). <https://doi.org/10.1186/s40100-022-00216-9>
- White, H (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica*, 48(4), 817. <https://doi.org/10.2307/1912934>
- Working, H (1943). Statistical laws of family expenditure, *Journal of the American Statistical Association*, 38(221), 43–56. <https://doi.org/10.1080/01621459.1943.10501775>