# FISH CONSUMPTION AND IMPLICATIONS FOR HOUSEHOLD NUTRITION AND FOOD SECURITY IN TANZANIA AND GHANA

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**ABSTRACT**

Food security encapsulates the dimensions of food availability, food access, utilization and stability. While food availability emphasizes the presence of food in an appropriate quality and quantity, food access stresses the ability to acquire the amount of food necessary for a nutritious diet. Thus, food security of households depends to some extent on the diversity in the diet. The more diverse the diet, the greater the probability that the nutritional needs of households are being met. In terms of food access, under-provision of infrastructure and services enhances the remoteness of a location, which translates into inflated food costs. For example, poor roads increases transportation costs for goods and services to a locality, and combined with lack of telecommunication networks makes access to food expensive. Therefore, this study examined household food security improvements through fish farming and seafood consumption in Ghana and seafood accessibility in Tanzania. In Ghana, the study focused on dietary diversity and seafood consumption while in Tanzania, the study focused on the impact of infrastructural features on access to seafood by Tanzanian households.

The study in Ghana utilized the Food Consumption Score (FCS), a measure of dietary diversity as a proxy for food security. FCS involves the collection of information on food consumed by households and are weighted according the energy content of the food item. The results suggested that fish farming households have higher food diversity and frequency of food consumed than non-fish farming households through direct consumption, and to some extent through the income effect. In addition, households in the savannah zone, especially in the rural areas were found to have a higher probability of improving their food security status by engaging in fish farming. Also, a household's probability of attaining high food security increases with fish farming as an extra source of income assuming the household is engaged in other non-fish farming related ventures. Post estimation analysis showed that a household in the rural savannah ecological zone with a female household head engaged in fish farming, has a probability of 96% of being food secure. On the margin, the probability of adopting fish farming increased with wealth, location, ecological zone and household size but decreased with household income per capita.

Regarding seafood consumption, the study used a Latent Class Model (LCM) of structural heterogeneity to model demand. The results suggested that Ghanaian consumers fall into two classes, which we refer to as 'Conservative' households and 'Progressive' households. For Conservative households, fish and poultry are complementary goods while fish and red meat are substitutes. For Progressive households, fish and poultry are complementary goods while fish, red meat and pork are substitutes. The potential reasons for the substitutability of fish over other animal proteins may relate to economical, dietary diversity, health and nutrition related factors and taste. Price is a major concern for consumers in the rural and peri-urban areas, who tend to be more Conservative, while taste, dietary diversity, health and nutrition concerns pertain to urban consumers, who tend to be more Progressive. An increase in the number of years of education of Conservative households reduces the consumption of fish but education has no impact on fish consumption by Progressive households.

Conservative households are identified as being Akan Christians, and located in the forest and savannah areas while Progressive households are identified as a mixture of Akan, Ewe and Dagomba. Religion does not affect fish consumption by Progressive households, located in mainly the savannah areas. Based on these results, it is recommended that producers take advantage of lifestyles and belief systems to improve marketing of seafood in Ghana by adopting consumer targeting, market segmentation, and positioning strategies in marketing their fish.

In Tanzania, accessibility to seafood was evaluated through the impact of infrastructural features such as electricity, communication networks and transportation. Two measures of seafood accessibility were used, i.e., Fish Accessibility Count (FAC), which is simply the total count of outlets a household visited over the period of data collection to obtain fish; and a Food Accessibility Index (FAI), an index constructed from a household's FAC, weighted by the population and average accessibility count in the enumeration area. The regression results showed that access to seafood by rural, urban and peri-urban households is determined by different factors. Access to transportation is a significant determinant of access to seafood by urban households, access to electricity improve access to seafood by rural and peri-urban households while access to communication improve access to seafood by rural and urban households. Other significant determinants of access to seafood include price, household size, age, education of the caregiver, the caregiver being married, and employment. A comparison between the FAC and FAI estimates shows that the estimated coefficients from the FAI are smaller in magnitude than estimates from the FAC model. The outcome of this study highlights the importance of infrastructure in Tanzania to seafood accessibility, particularly electricity, communication and transportation.

## INTRODUCTION

The concept of food security has evolved over the years with initial focus on the volume and stability of food supplies. However, in 2001, the FAO redefined food security as "… *a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*" (FAOa, 2002). Thus, food security of households depends to some extent on the diversity in the diet. The more diverse the diet, the greater the probability that the nutritional needs of households are being met. Similarly, lack of infrastructure heighten food insecurity. Poor road systems, inefficient market distribution and infrastructure systems such as post-harvest storage systems and unpliable roads hinder accessibility to food including seafood in many developing countries.

Fish is an important contributor to food security in Ghana and Tanzania, especially when food security is defined beyond the confines of availability and accessibility to encompass the nutritional content of food. Fish is an important source of proteins, essential micronutrients and minerals in the diet of most African households but supply is low so is the consumption levels of fish. The sub-region has the lowest per capita fish consumption in the world, nevertheless, it is projected that, in order to maintain current levels of fish consumption in Africa, an additional 1.6 million tons of fish is needed (WorldFish, 2009). Several developmental interventions in Africa related to fish consumption, aquaculture, and capture fisheries have aimed at improving the nutritional status of households through direct dietary intake, production and increase in household income (Kawarazuka, 2010).

The nutritional impact pathways of fish could come from fish farming, where the household consumes fish harvested from their pond, and/or from other indirect ways such as selling the harvested fish to increase the food purchasing power (income effect) of the household to purchase nutritious foods. Several factors are critical to the nutritional decisions of household such as income, tastes, education, family size and composition and market price (Abdulai and Aubert, 2004). The income and price factors represent the purchasing power and availability of food in the house, tastes represent food preferences, education etc., family size and composition depict the per capita purchasing power and food availability.

Food security encapsulates the dimensions of food availability, food access, utilization and stability. While food availability emphasizes the presence of food in an appropriate quality and quantity, food access stresses individuals' ability to acquire the amount of food necessary for a nutritious diet (FAO, 2006). Thus, under-provision of infrastructure and services enhances the remoteness of a location, which translates into inflated food costs. Poor roads increase transportation costs for goods and services to a locality and this combined with lack of telecommunication networks makes access to food expensive. The lack of food market information is very important as it hinders trade between rural and urban food producers and traders. Communities poorly connected to major food marketing centers suffer from the risk of uncertainty surrounding food production and marketing (Llanto, 2012, Temu et al., 2005).

## OBJECTIVES

1. Measure household food security in terms of dietary diversity using indicator measures in Ghana
2. Analyze household food security in terms of seafood accessibility using infrastructure features in Tanzania
3. Analyze the determinants of household consumption practices of various food types including fish in Ghana
4. Formulate policy measures to improve fish consumption and subsequently, improve household food security in Ghana and Tanzania.

This study examined household food security improvements through seafood consumption in Ghana and seafood accessibility in Tanzania. For Ghana, the study focused on dietary diversity and seafood consumption while for Tanzania, the study focused on the impact of infrastructure features on access to seafood by Tanzanian households.

## METHODS

### Data and Study Design - Ghana

This study adopted the Food Consumption Score (FCS) method to assess food security in the Propensity Score Matching (PSM) framework. Fish farming households were classified as the *treated* group while non-fish farming households were classified as the *control* group. FCS is a measure of dietary diversity and involves the collection of information of food consumed by households and weighted according the energy content of food item (WFP, 2009). The food groups include cereals, roots and tubers, vegetables, fruits, meat, offal, poultry, eggs, fish and seafood, pulses / legumes / nuts, milk and milk products, sugar / honey, oils / fat, and condiments / miscellaneous. Supplemental data used in the analysis included the 2012/2013 Ghana Living Standards Survey (GLSS) data published in August 2014. The GLSS data has information on a range of factors including the living conditions and well-being of households in Ghana, demographic characteristics of households, education, health, employment, housing conditions, household agriculture, household expenditures, income and their components, access to financial services, and assets. There is information on 16,772 households from all ten regions of Ghana in the dataset, but information on 4,011 household was used that included 144 fish farmers. The sample size was determined after using influence diagnostics to identify observations that influence the variance. Using *rstudent* thresholds, observations were dropped if their *rstudent* values were outside the range of $2 \geq r \leq -2$. The rstudent was used to identify variables of influence, which significantly affected the model fit. Normally, observations with rstudent larger than 2 in absolute value need attention because of their pull on the dependent variable (Boomsma, 2014; SAS, 1999).

The analysis on seafood consumption utilized a Latent Class Model (LCM). Data used for the analysis involved information on 2,641 households in the GLSS database. This sample size was established after recognizing missing data on fish consumption, market prices and education. A significant portion of the GLSS database (13,300) was for households that had not purchased any of the animal protein of interest for this study during the period of data collection. Households with missing data on education and fish expenditure were also dropped, resulting in our sample size of 2,185. The information about the sample used covered the community, household, and individual levels on demographics, socioeconomic factors, expenditure and market prices.

***Propensity Score Matching (PSM)***

PSM is a quasi-experimental approach that reduces the estimation bias in measuring the impact of a treatment (in this study, fish farming) on an outcome (in this study, food security proxied by FSC) with observational data. PSM involves two stages; the first is a logit regression with the treatment variable as the dependent variable to estimate the adoption decision as a function of household observable characteristics. Propensity scores for both the *treated* (fish farming) and *control* (non-fish farming) were generated using the predicted results from the logit regression. Using matching algorithms, the *treated* and *control* households were paired up. The second stagewas the determination of the impact of the fish farming adoption decision on the outcome variable (household food security). The impact of the adoption decision on the outcome variable is estimated by calculating the net impact of adopting fish farming on the household's food security (Baker, 2000). The basic set up for PSM was;

$$Y_1 = \beta_1 X + \varepsilon_1$$
$$Y_0 = \beta_0 X + \varepsilon_0 \qquad (1)$$

where $Y_1$ is the outcome variable for the *treated* group; $Y_0$ is the outcome variable for the *control* group; $X$ is the vector of observed characteristics for both c*ontrol* and *treated* groups, $\varepsilon_1$ and $\varepsilon_0$ represent the error terms assumed to be exogenous of the vector of observed covariates.

The focus of the analysis was the correlation of participation in fish farming denoted by $F$ and household food security. If a household is participating in fish farming ($F = 1$), the expected average outcome of food security is $E(Y_1|F = 1)$ and the counterfactual situation when the household is not participating in fish farming is $E(Y_0|F = 1)$. The counterfactual is unobservable, however the food security outcome of a non-fish farming household ($F = 0$), $E(Y_0|F = 0)$ was observed. Therefore, the Average Treatment on the Treated (ATT) was estimated as;

$$ATT = E(Y_1 - Y_0|F = 1)$$
$$= E(Y_1|F = 1) - E(Y_0|F = 1) \qquad (2)$$

The PSM used the observed mean of the food security outcome of non-fish farming households who are similar to the fish farming households in the observed characteristics, i.e., it uses $E(Y_0|F = 0)$ to estimate $E(Y_0|F = 1)$;

$$E(Y_0|F = 1) - E(Y_0|F = 0) = 0 \qquad (3)$$

Equation (3) ensures that there is no bias from self-selection in the ATT.

***FCS as a Food Security Indicator***

For FCS, a measure of dietary diversity to be a valid indicator of food security, it has to capture food accessibility, availability, utilization and stability (Kennedy et al. 2010; Hoddinott and Yohannes, 2002). Household per capita income and wealth index were used as food security indicators because the strength of correlation validates FCS as a proxy measure of food security. From Table 1, FCS is correlated at the 5% level with household income (0.036), wealth index squared (0.051) and per capita household income (0.04), indicating a strong validation.

**Table 1.** Correlation of FCS with Other Food Security Indicators

| Variable | FCS | Wealth index squared | Per capita household income | Household income |
|---|---|---|---|---|
| FCS | 1.000 | | | |
| Wealth index squared | 0.051* | 1.000 | | |
| Per capita household income | 0.040* | 0.012 | 1.000 | |
| Household income | 0.036* | -0.050* | 0.894* | 1.000 |

Note: * indicates statistical significance at 5% level

The determinant variables used to assess the impact on food security include, ecological location; fish farming; household wealth; household per capita income; household size; and the educational level, age, marital status, employment status, and gender of household head.

***The Latent Class Model (LCM)***

To model household fish consumption, a household is assumed to maximize utility from the best combination of commodities, subject to time, resources and technology. To address heterogeneity among households in the sample, a form of cluster analysis was applied, specifically the LCM. The LCM assigns households into classes, which is determined through probabilities. This avoids bias and randomness in sample selection. The LCM analysis simultaneously models the demand function with households classified into different expenditure classes. Tastes and preferences are assumed to be homogenous within a class, but differ across the classes (Birol et al., 2011). The allocation of a household to a particular class is purely probabilistic and it is dependent on the household's characteristics. The prior probability of a household belonging to a particular class in the presence of household characteristics $k_i$ is modeled as:

$$P[class\ c|k_i] = N[\beta_c' x_i, \sigma_c^2] = F_{ic} = \frac{\exp(\theta_c', k_i)}{\sum_{c=1}^{C} \exp(\theta_c', k_i)}, \theta_C = 0 \quad (4)$$

Since $k_i$ contains variables, a class specific variables are normalized to zero to identify the model. The standard errors are then bootstrapped to take care of outliers in the data and enhance asymptotic inference of the results.

The variables used for the LCM analysis included Fish Expenditure for a period of 7 days measured in Ghana cedis, which is the dependent variable. It includes all forms of fish, fresh, dried, smoked, salted and canned. The independent variables include market prices in Ghana cedis (Ghc) for red meat (goat meat, mutton, and beef & canned beef) and poultry (chicken); demographic factors, i.e., years of education, marital status, monthly income (proxied with total household expenditure in Ghana cedis), being employed, and age of household head; geographical location, i.e., coastal, forest, savannah (Sudan Savannah, Guinea Savannah and Coastal savannah) and the Greater Accra Metropolitan Area (GAMA); and cultural and religious factors, i.e., ethnicity and religious affiliation. The categories for the ethnic groups are Akan, Ewe, Ga, Guan, Dagomba and foreigners, and the religious affiliations are traditional, Islamic and Christian religions.

Although the data is cross sectional, households were surveyed in different months from the 4th quarter of 2012 through the 3rd quarter of 2013. Quarters were therefore included to capture inflation as well as seasons and occasions such as the Ramadan for the Muslims and other seasonal festivities.

**Data and Study Design - Tanzania**

Data for the analysis are from the Tanzania 2011/12 Household Budget Survey (HBS). The data were collected with structured questionnaires that solicited information on household and community demographics, socioeconomic, individual and health issues. The database contains information on

10,186 households from all 19 regions of Tanzania Mainland. Tanzania is divided into smallest units by land area called enumeration areas (EA), which are the next lowest cluster level after household level. There are 400 EAs with 26 households in each EA. This study utilized information on 1,730 households with data pertaining to household and community infrastructure and seafood accessibility. The variable *education* had about 8,000 missing values. We did not want to assume that households with zeroes and missing values were the same, so we dropped the households with missing values but left those with zeroes.

To assess seafood accessibility, there is a need to develop a measure of accessibility. This was accomplished with two different measures; (1) Fish Accessibility Count (FAC), which is simply the total count of outlets a household visited over the period of data collection to obtain fish; (2) a Fish Accessibility Index (FAI), which captures the heterogeneous nature of the location of these households. FAI weights each household's accessibility count by the total population and average accessibility count of its EA.

***Fish Accessibility Index (FAI) as Food Access Indicator***

In the Tanzania HBS data, households disclosed the outlets where they obtained fish. These include market, permanent shop, street vendor, supermarket, department store, other household, other, own production, gift from neighbors, food aid and gathering. The most frequented outlets were the market, shop and other unknown source(s). Each household's FAI is created as follows:

$$\text{FAI} = \frac{T - m_i}{n - 1} \qquad (5)$$

where $T$ is the total accessibility count for each EA., $m_i$ is the average accessibility count of an enumeration area and $n$ is the total number of households in the sample. It is expected that a more urbanized area and densely populated area will have more food outlets than otherwise. This has been the observation in most studies particularly in developed countries.

To validate FAI as a measure of fish access, it must capture two main components of food access; physical access (distance to market, number of food outlets in a location) and economic access (household income, market price of fish, quantity of food purchased). The FAI as a valid measure of seafood accessibility must also be correlated but not perfectly with these measures of access. A perfect correlation implies FAI is just measuring exactly the other measure of access. However, a significant but not perfect correlation between FAI and other measures of access is indicative of the difference between FAI and the other measures of access. From Table 2, FAI is correlated at the 5% level with access count (0.44). This means that the physical aspect of access explains about 44% of FAI.

**Table 2.** Correlation of FAI with Other Food Access Indicators

| Variable | FAC | Price | Quantity of fish | FAI |
|---|---|---|---|---|
| FAC | 1.000 | | | |
| Price | -0.096* | 1.000 | | |
| Quantity of fish | -0.0214 | 0.317* | 1.000 | |
| FAI | 0.443* | -0.023 | -0.011 | 1.000 |

Note: * indicates 5% significance level

Two regressions were estimated with the FAC and with the FAI as the dependent variables. The regressions used control variables to capture both the observable and unobservable factors influencing seafood accessibility. The conceptual regression equation of the household seafood accessibility model is:

$$\ln(y_i) = \beta_0 + \beta_i x_i + \ln(s_i) + \mu_i \qquad i = 1, \ldots, n \qquad (6)$$

where $y_i$ is the dependent variable, seafood accessibility; $x_1$ to $x_n$ are exogenous independent variables of age, married, mother's education, household size, geographical location, sex of caregiver, and employment status; and $s_i$ represents household monthly income, price of seafood and expenditures on transportation, electricity and communication. ln (.) denotes an inverse Hyperbolic Sine Transformation (IHS) which is a log-like transformation that allows the zero and negative values in the observations. The transformation takes the form of $= \ln(d_i + (d_i^2 + \theta)^{0.5})$, where θ = 1, is employed as IHS (see examples in Bellemare et al., 2017; MacKinnon and Magee, 1990). Since the IHS is a log-like transformation, the coefficients on price and income can be interpreted as elasticities. To incorporate the heterogeneous nature of individual households, the variances for equation (6) is estimated with equation (7) below to obtain White's standard errors as heteroscedasticity-robust standard errors:

$$Var(\hat{\beta}) = (X'X)^{-1}X \sum X(X'X)^{-1} \tag{7}$$

These standard errors are asymptotic and so inferences can be made about the entire population in the presence of any kind of heteroscedasticity, including homoscedasticity (Greene, 2003).

The Tanzania HBS database has information on the expenditure on community features by the household and that is what is used as proxy measures for access to transportation, electricity and cell phone networks. Access to electricity is the household's monthly expenditure on electricity in Tanzanian shillings (TZS); Access to Communication Networks is the household's monthly expenditure on mobile phone and internet use in TZS; and Access to transportation is the monthly expenditure of the household on transportation in TZS.

## RESULTS AND DISCUSSION - GHANA

In order to estimate the impact fish farming has on household food security, the ATT was calculated after matching, and the results are shown in Table 3. All matching algorithms show similar results that on average, adopting fish farming significantly increases food security of households as measured by the FCS. The average improvement in food security is between 13.9 and 15.5 points. This increase in food security can be translated food-wise / dietary diversity into consuming fish at least twice a week; roots/tuber or cereals, pulses and legumes once a week; fats and oils or sugar and sugar products at least once a week; and vegetables or fruits at least twice a week.

**Table 3.** Impact of Fish Farming Participation on Household Food Security

| Variables | Matching Algorithm | Treatment | Control | ATT | BSE | t-stat | FFH | nFFH |
|---|---|---|---|---|---|---|---|---|
| FCS | NNM (1) | 69.77 | 54.23 | 15.54 | 1.71 | 9.11 | 143 | 3867 |
| | NNM (5) | 69.77 | 54.28 | 15.54 | 1.44 | 10.78 | 143 | 3867 |
| | KBM (0.03) | 69.77 | 55.30 | 13.86 | 1.38 | 10.31 | 143 | 3867 |
| | KBM (0.06) | 69.50 | 55.64 | 13.86 | 1.34 | 10.35 | 143 | 3867 |

NNM = Nearest Neighbor Matching; KBM = Kernel Based Matching
BSE = Bootstrapped standard errors with 100 replications
FFH = Fish farming Household; nFFH = non-Fish Farming Household

The major pathway through which fish farming contributes to poverty alleviation and economic development in Ghana is the multiplier effect (Kassam, 2014). However, from the findings in this study, the effect is direct consumption. It can be concluded that a household that participates in fish farming has a higher probability of achieving higher food security because of increased access and availability.

The results from the matching procedures are shown in Table 4. The results show whether the algorithm used was able to balance the distribution of the important covariates in the *treated* and *control* groups. There was significant percentage reduction in biases as seen in Table 4. No significant differences are seen between fish farming and non-fish farming households for any of the covariates after matching.

**Table 4**. Tests for Selection Bias after Matching

| Variables | Matched sample | | | | |
|---|---|---|---|---|---|
| | Treated | Control | %Bias | Bias Reduced | t-test p-value |
| Wealth index squared | 2.16 | 1.86 | 10.8 | 47.4 | 0.48 |
| Wealth index | 0.12 | 0.11 | 1.0 | 95.8 | 0.94 |
| Education | 7.76 | 6.76 | 15.7 | 47.4 | 0.18 |
| Age | 45.99 | 46.24 | -2.1 | 82.8 | 0.88 |
| Peri-urban | 0.21 | 0.24 | -8.2 | 79.5 | 0.57 |
| Married | 0.93 | 0.92 | 2.1 | 94.2 | 0.82 |
| Employed | 0.97 | 0.99 | -10.3 | 22.9 | 0.41 |
| Sex | 0.92 | 0.93 | -2.2 | 91.5 | 0.82 |
| Location | 2.62 | 2.57 | 7.8 | 80.4 | 0.50 |
| Income/capita | 63.09 | 56.01 | 1.8 | 96.2 | 0.61 |
| Household size | 7.69 | 8.36 | -16.3 | 68.8 | 0.24 |

***Effects of Ecological Zone and Female-Headed Households on Food Security***

The FCS thresholds of *Poor* (0 - 21), *Borderline* (21.5 - 35) and *Acceptable* (above 35) were used as dependent variable for further analysis, and the probabilities of households belonging to any of these categories calculated. The majority of the sample were located in the rural area, so to assess how rural households can improve their food security status; the variables were analyzed using a representative household: Being a fish farmer, a household with an educated female head, and living in the rural savannah ecological zone. The interest in the savannah ecological zone is because the three Northern regions (Upper East, Upper West and Northern) have the highest prevalence of food insecurity (Table 5). In addition, it was observed from the analysis that moving away from the coast towards inland (forest and savannah ecological zones) increases the probability of adoption of fish farming.

**Table 5.** Food Consumption Scores by Region

| Region | Min(FCS) | Max(FCS) |
|---|---|---|
| Western | 32 | 84.5 |
| Central | 39 | 88 |
| Greater Accra | 60 | 88 |
| Volta | 31.5 | 89.5 |
| Eastern | 34.5 | 85 |
| Ashanti | 25 | 112.02 |
| Brong Ahafo | 17.30 | 109 |
| Northern | 33 | 71 |
| Upper East | 30.5 | 73.5 |
| Upper West | 27 | 73.5 |

The post estimation results show that a household in the rural savannah ecological zone with a female household head engaged in fish farming, has a higher probability of being food secure (96%) as shown in Table 6.

**Table 6.** Probability of Improving Food Security in Rural Savannah Zone for Female Fish Farmer Household Head

| Variable | Predicted prob. |
|---|---|
| Poor | 0.001* (0.00) |
| Borderline | 0.036* (0.01) |
| Acceptable | 0.963*** (0.01) |
| Observations | 4,000 |

Standard errors in parentheses
*** represents p<0.01, ** p<0.05, * p<0.1
NOTE: ALL other regressors at their mean value

### *Effect of Income Diversification on Household Food Security*

Income diversification is another way of improving household food security. It helps to reduce risks associated with the households' ability to access food. Therefore, the ability of the household to increase its probability of access to food may increase if household income sources are diversified. Three different scenarios were simulated with three different income sources: (1) Non-fish farming income only, (2) income from fish farming plus non-fish farming (diversified income), and (3) income from only fish farming. Results of these simulations are presented in Table 7. The results show that the probability of households increasing their food security status increases with a diversified income source (89%), with only income from fish farming (86%) and with non-fish income (85%). The probabilities of being food insecure are very low; 0.004 for food poor with no income from fish farming, 0.004 with income from fish farming and 0.003 with a diversified income source. All estimates are statistically significant at the 1% level. These outcomes imply that household's probability of attaining food security increases with fish farming as an extra source of income assuming the household is engaged in other non-fish farming related ventures.

**Table 7.** Predicted Probabilities of Achieving Higher Food Security with Income Diversification

| Variables | Predicted prob. |
|---|---|
| Poor with non-fish income | 0.004*** (0.01) |
| Poor with fish income | 0.004*** (0.00) |
| Poor with diverse income | 0.003*** (0.00) |
| Borderline with non-fish income | 0.142*** (0.01) |
| Borderline with fish income | 0.133*** (0.02) |
| Borderline with diverse income | 0.112*** (0.01) |
| Acceptable with non-fish income | 0.854*** (0.01) |
| Acceptable with fish income | 0.863***(0.02) |
| Acceptable with diverse income | 0.885*** (0.01) |
| Observations | 4,000 |

Standard errors in parentheses
*** represents p<0.01, ** p<0.05, * p<0.1
NOTE: All regressors at their mean value

### *Latent Class Linear Regression Results*

The LCM predicted 2 Classes of consumers. Table 8 shows the predicted probabilities of households belonging to each of the classes. The probability of a household in the sample belonging to Class I is 72.1% while belonging to Class II is 27.9%.

**Table 8.** Estimated Class Probabilities

| Class | Probability |
|---|---|
| Class I | 0.721 |
| Class II | 0.279 |

Note: * p<0.1, ** p<0.05, *** p<0.01

Table 9 shows class membership, which is determined through age and employment. By examining the results in Table 9 further, we refer to Class I households as 'Conservative' households and Class II households as 'Progressive' households. This is because the Conservative class of households show some common characteristics of fish consumption among Ghanaian households, especially in rural and peri-urban areas. According to Heinbuch (1994), consumers in rural households choose fish because it is cheap while consumers in the urban areas consume fish for health and nutritional reasons. For Progressive households, employment is a stronger determinant (12.2%) for class membership while age is the major determinant for Conservative households (96.2%).

Demand for fish is price inelastic among Conservatives but relatively more elastic compared to Progressive households, which is approximately unitary elastic. When the price of fish increases by 1%, the consumption of fish decreases by 0.92% among Conservative households and approximately 1.00% among Progressives (Table 9). For Conservative households, fish is complementary to poultry but a substitute for red meat. Progressive households also consider poultry as a complement to fish but red meat and pork as substitutes. Potential reasons for the substitutability of fish over other animal proteins are economical, health and nutrition related factors and taste (Heinbuch, 1994). Price is a major concern for consumers in the rural and peri-urban areas, who tend to be more Conservatives while taste, dietary diversity, health and nutrition concerns pertain to urban consumers, who tend to be more Progressive. The literature has largely reported the health benefits of eating fish relative to other types of meats (Lajous et al. 2012; Wurtz et al. 2016, Sui, et al. 2016), which might be some of the reasons for the observed shift from red meat to fish in households. Goat meat, beef and pork (in the form of pig feet) are quite popular among Ghanaian households, but are consumed in small quantities in rural areas. Pork and poultry are popular in households in urban areas (Essuman, 1990).

**Table 9.** Estimated Parameters of the Latent Class Linear Model for the 2 Classes

| Variables | Conservatives | BSE | Progressives | BSE |
|---|---|---|---|---|
| Fish price | -0.922** | 0.037 | -0.998*** | 0.000 |
| Poultry price | -0.053*** | 0.024 | -0.001*** | 0.000 |
| Red meat price | 0.107** | 0.023 | 0.001*** | 0.000 |
| Pork price | -0.053 | 0.033 | 0.001*** | 0.000 |
| Akan | 0.118** | 0.054 | 0.007*** | 0.001 |
| Ewe | 0.067 | 0.071 | 0.013*** | 0.001 |
| Ga | -0.110 | 0.086 | 0.002 | 0.001 |
| Guan | -0.035 | 0.077 | -0.029*** | 0.002 |
| Dagomba | -0.168** | 0.084 | 0.003*** | 0.001 |
| Islamic | -0.060 | 0.061 | 0.000 | 0.001 |
| Christian | 0.039 | 0.046 | 0.001* | 0.000 |
| Coastal | -0.049 | 0.055 | 0.001* | 0.000 |
| Forest | 0.173*** | 0.041 | -0.003*** | 0.000 |
| Savannah | 0.182*** | 0.058 | 0.003*** | 0.001 |
| Education | -0.016*** | 0.005 | 0.000** | 0.000 |
| Monthly income | 0.126*** | 0.021 | -0.001*** | 0.000 |
| Married | -0.040 | 0.031 | 0.002*** | 0.000 |
| Male | 0.010 | 0.030 | -0.004*** | 0.001 |
| 1st quarter (Q1) | -0.129*** | 0.042 | -0.006*** | 0.000 |
| 2nd quarter (Q3) | 0.026 | 0.051 | -0.001* | 0.000 |
| 3rd quarter (Q4) | 0.137*** | 0.042 | 0.003*** | 0.001 |
| Constant | 2.959*** | 0.170 | 0.008*** | 0.002 |
| Fixed Parameters | | | | |
| Constant | -0.509*** | | | |
| Age | 0.038*** | | | |
| Employed | -0.122** | | | |

Note: * represents $p<0.1$, ** $p<0.05$, *** $p<0.01$, BSE = Bootstrapped standard errors with 100 replications

The FAO (2002b) reported that human diets have evolved significantly in developing countries largely influenced by rapid urbanization. Changes in population and income levels are resulting in dietary diversity in the urban areas of Accra, Kumasi, Sekondi-Takoradi and Cape Coast in Ghana (Osei-Asare and Eghan, 2014). Such lifestyle aligns more with Progressive households.

Fish consumption among Conservative households increases by 12% if they belong to the Akan ethnic group, and by 17% and 18% respectively if located in the forest and savannah areas (Table 9). Fish consumption by Progressive households increase by 0.7% when they are affiliated with the Akan ethnic group and by 1.3% and 0.3% respectively when they belong to the Ewe and Dagomba ethnic groups. Consumption of fish also increases by 0.1% and 0.3% respectively if a Progressive household is in the coastal and savannah areas and by 0.1% if they identify as Christians. The relative impact of the ethnic and location variables is generally stronger with Conservatives than the Progressives (Table 9).

The fish elasticities obtained for Conservatives and Progressives are typical for households located in the forest, coastal and savannah areas. Forest and savannah dwellers tend to consume less fish compared to coastal dwellers due to availability because of proximity to landing sites. This could also explain the relatively less-price elasticity of fish to Conservative households and the substitutability of red meat because of readily available red meat in the forest and savannah regions. The unitary price elasticity of fish among Progressives could indicate the availability of fish because of proximity as well as health and nutrition concerns.

The impact of education is mixed. An additional year in school decreases the fish consumption by 1.6% among Conservative households (Table 9). Education seems to have very minimal effect on fish consumption in Progressive households. Progressive households may be more conscious about the health benefits of animal proteins in general, therefore their consumption of fish may not be driven by education level but their lifestyle, taste and preferences. Conservative households, on the other hand, may be driven by economic factors.

Household income is one of the major variables that significantly impacts fish expenditures. With an increase by 1%, the demand for fish increases by 0.13% among Conservative households, but decreases by 0.001% among Progressive households (Table 9). Because the expenditure on fish is increasing when income is increasing, we can assume that fish is a normal good to Conservative households but an inferior good to Progressive households. The results appear to make economic sense because according to the Engle's Law, high-income households tend to lean more towards dietary diversity, taste and nutrition rather than quantity (Jensen and Miller, 2011) while meeting their daily caloric requirements. Similar results are reported in the literature. For example, Amao (2006) found that for urban households, fish is an inferior good since income elasticity is negative. Tambi (2001) also reports result for high-income households in Cameroon and observed that they reduced their fish consumption with an increase in income. However, contrary results were reported by Anyanwu (2014) who analyzed the socioeconomic drivers of fish consumption among households in Nigeria and reported that fish is a normal good in high income households.

Marital status and gender of household head significantly impact fish consumption by Progressive households and not Conservative households, especially when the household head is married and a female (Table 9). However, male-headed households have been reported to influence fish consumption in Nigeria (Anyanwu, 2014). In Ghana, the woman is mostly the one that prepares meals in typical households and may decide what the household consumes for the day. In urban regions, gender roles are becoming less rigid because food-away from home is more available, and there is no clear indication of who makes the decision of what to eat (Lee and Tan, 2006, Ham and Yang, 1998).

However, the result obtained here corroborates studies on the effect of gender and households on food consumption, where households with female heads tend to have positive consumption of animal source protein in general while male heads tend to decrease the consumption of such foods (Plataroti, 2016).

***Processed Fish Expenditure by Location and Ethnicity***

The hypothesis that location and ethnic affiliation have no effect on fish consumption was tested using the Wald test of linear restrictions. The chi-squared value for ethnic affiliation is 10.29 and significant at the 1% level. The chi-squared value for geographical location is 11.31 and significant at the 1% level. This implies the variables are very important and that producers can take into consideration geographical location and ethnic affiliations in their seafood marketing approach to consumers.

A further analysis into the diverse types of processed fish consumed by location indicates that on average, smoked fish is the most consumed processed fish by all households (Figure 1). Households in the forest and coastal areas consume more smoked fish compared to the national average. Households in the savannah areas consume more dried fish while households in GAMA consume more fried fish. Fresh, frozen fish and crustaceans are consumed more in GAMA households. This is because they are relatively more expensive and households located in GAMA have higher purchasing power so they can afford and their tastes vary because of changes in lifestyle. Crustaceans on the average are the least consumed followed by salted and canned fish. Salted fish (*Koobi*) is a delicacy among households located in the forest and coastal regions. Figure 1 aligns with the 1978/1999 household survey as well as the 2008 fifth round of the GLSS indicating that fish expenditure has generally increased as a percentage of the overall Ghanaian households' food budget. The inelastic nature of fish price among Conservatives is also substantiated in Figure 1 with the forest region consuming the most fish. Even though Coastal and GAMA households also consume smoked fish, they consume the greatest amount of fresh fish. This supports the argument of health conscious consumers, normally found in urban areas preferring fresh foods to processed foods.

Expenditure on processed fish by ethnic group is presented in Figure 2. The Guans, Ewes, Akan, Ga and other ethnic groups consume more smoked fish while the Dagomba ethnic group consume more dried fish. Households affiliated with the Ga ethnic group also consume more fried fish than the national average. The Guan, Ga and Ewe ethnic groups have relatively higher consumption because of their proximity to landing sites (e.g. Tema port, Chorkor and the Volta Lake). This also explains their relatively higher consumption of fresh and frozen fish. The Dagomba ethnic group consume more dried fish because they are further away from fish landing sites and dried fish stores better than smoked fish, particularly for households.

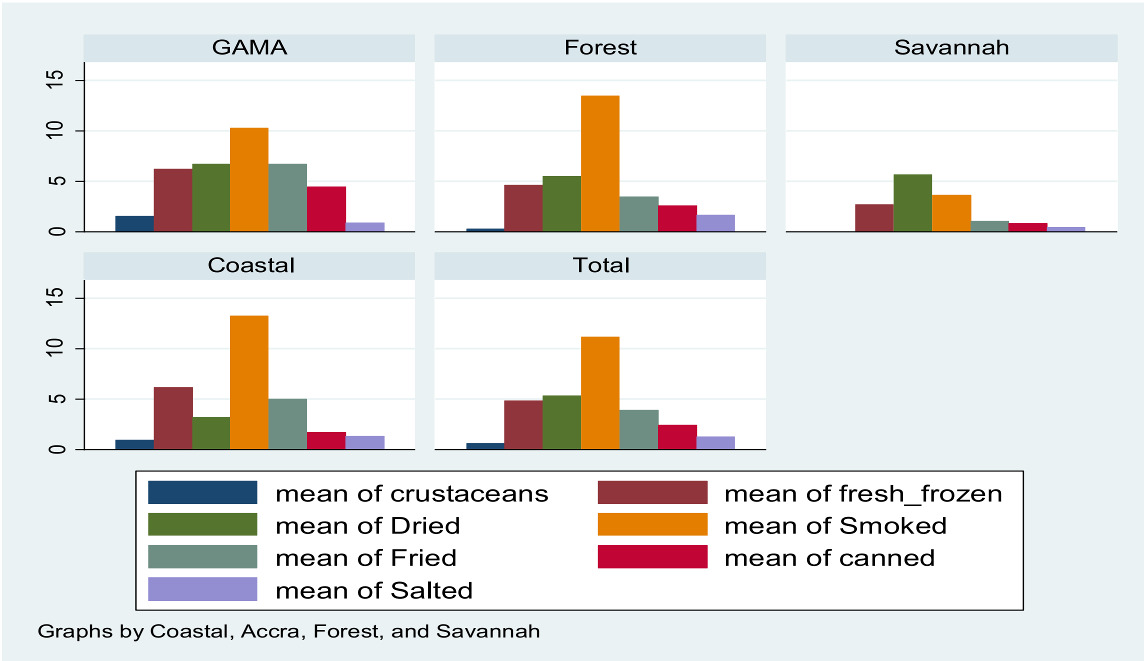


**Figure 1.** Expenditure for Processed of Fish by Location

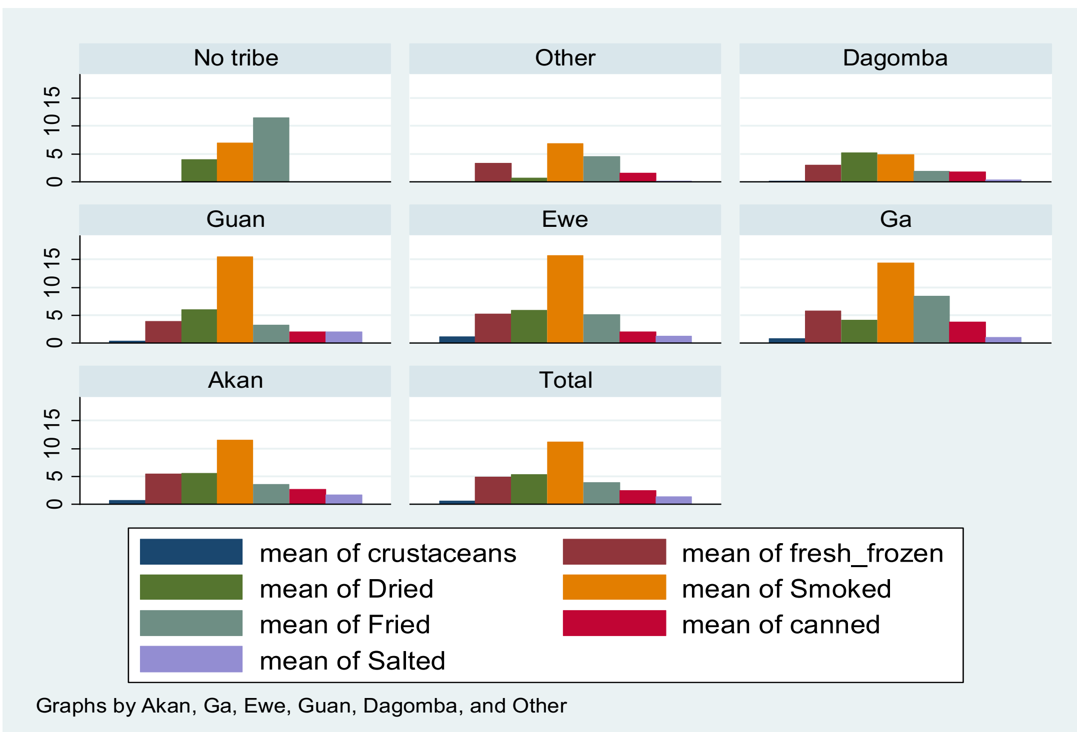


**Figure 2.** Expenditure of Processed Fish by Ethnicity

***Policy Recommendations for Ghana***

1) The findings suggest the promotion of fish farming in the three Northern regions, preferably aquaculture in water reservoirs using cages. The Northern regions are the least developed in the country, and cage fish farming requires low capital cost compared to land based fish farms. With

efficient stocking density, good returns on investment can be realized, and it requires very little labor and less maintenance. These advantages make cage culture quite suitable for low-income households. The existing irrigation schemes in the Northern and Upper East regions (Bontanga, Golinga, Ligba, Vea and Tono) for rice and vegetable production will be good sources of water for the cage fish farms.

2) Women should be encouraged to engage in more than processing of fish and getting involved in fish production as well. The simulation results have positive implications for increasing household food security with women as head of household. It is also recommended that further studies be done using a repeated cross section approach to assess the impact fish farming on household food security over a period.
3) Regarding seafood marketing, it is recommended that local fish producers in Ghana be educated on the importance of geographical location and ethnicity on fish demand. Fish producers can take advantage of lifestyles and belief systems to improve marketing of seafood in Ghana by adopting consumer targeting, market segmentation, and positioning strategies in marketing their fish.

## RESULTS AND DISCUSSION - TANZANIA

Households in rural areas of Tanzania face barriers that households in urban areas do not face when it comes to access to seafood and food in general. There are differences in access to seafood in the three locations examined, i.e., rural, urban and peri-urban. The results from the two regression using FAC and FAI over location are presented in Tables 10 and 11 respectively. The variables of interests here are the household's expenditure on electricity, communication and transportation.

### Regression Results with FAC as The Dependent Variable

From Table 10, the three variables of interest are positive and significant at the 1% level in certain locations. For households in rural locations, increased expenditure on communications, i.e., cell phone airtime implies increased communication between the household and other members of the community, both far and near. This may also imply an increase in the chances of locating the cheapest fish in the situation of price hikes or in the search for variety. As noted by Lashgarara, 2012; and Van Crowder and Fortier (2000), the more access the household has to ICT and information services, the higher the chances of reducing the food insecurity status if the household, which includes accessibility to seafood.

For peri-urban households, an increase in access to electricity increases accessibility by 0.05% with a 1% increase but decreases accessibility to fish by 0.01% with a 1% increase in transportation costs (Table 10). Electricity is a measure of technological access so if households are increasing expenditure on their electricity consumption, they might also have storage and preservation appliances like refrigerators and electric cookers, which increases their access to perishable foods like fresh fish. Peri-urban areas are located on the outskirts of urban areas. An increase in the number of outlets visited will typically mean an increase in transportation costs for household living outside the commercial district or urban areas. Households living in peri-urban areas particularly around Dar es Salaam will benefit from the Dar Rapid Transit (DART), which has been successful since its inception in 2016.

**Table 10.** Determinants of Household Accessibility to Seafood by Location using FAC

| Variables | Rural | Urban | Peri-Urban |
|---|---|---|---|
| Electricity | -0.236 (0.212) | -0.079 (0.054) | 0.054***(0.008) |
| Communication | 0.089***(0.027) | 0.004 (0.031) | 0.008 (0.007) |
| Transportation | 0.019 (0.021) | 0.021 (0.006) | -0.014***(0.004) |
| Price of seafood | -0.581***(0.096) | -0.014 (0.073) | 0.024 (0.017) |
| Age | -0.010** (0.003) | 0.006* (0.003) | -0.001 (0.001) |
| Household size | -0.017* (0.009) | -0.005 (0.015) | 0.006** (0.002) |
| Female | 0.184 (0.082) | -0.020 (0.076) | 0.011 (0.016) |
| Married | 0.175 (0.107) | 0.103 (0.087) | 0.044** (0.018) |
| Unpaid employee | 0.019 (0.160) | 0.049 (0.154) | -0.049 (0.032) |
| Paid employee | 0.048 (0.139) | 0.030 (0.130) | 0.008 (0.028) |
| Education | 0.010 (0.011) | -0.001 (0.008) | -0.005*** (0.002) |
| Household income | 0.124 (0.022) | 0.001 (0.017) | -0.006 (0.002) |
| Constant | 0.946***(0.251) | 1.263***(0.212) | 1.280*** (0.046) |

Note: *** indicates $p < 0.001$, ** $p < 0.05$, and * $p < 0.10$; Robust standard error in parenthesis.

Age, marital status and years of education of the caregiver, household size and market price of fish significantly influence the household's accessibility to seafood. For households in rural areas, access to seafood is reduced with an increase in the price of fish, age of the caregiver and household size (Table 10).

The high dependence of rural households on food consumptions and variants of food prices directly translate into reduced purchasing power and rising rates of food insecurity, which leads to compromises in dietary quality and quantity (FAO, 2009). While access to seafood increases for urban households with an increase in age. An increase in the years of education reduces access to seafood in peri urban households but increases with household size, and when the caregiver is married.

***Regression Results with FAI as the Dependent Variable***
Table 11 presents results with FAI as dependent variable. The estimated coefficients with FAI as the dependent variable is assumed less biased and more consistent relative to the coefficients in Table 10. The differences observed are that electricity and communication are significant determinants of seafood accessibility in rural and urban households respectively. Correcting for possible influence of the built-in environment of the household's location increases access to seafood for rural households when expenditure on electricity increases (Table 11). This implies availability of electricity enhances the household's access to seafood. An increase in expenditure in communication in rural households also significantly increase their access to seafood. The magnitude of the coefficient for rural households is smaller compared to the coefficient on electricity in Table 10.

Increase in communication expenditure also increases accessibility to seafood in urban households by 0.02%. Access to cell phones increases the connection among the rural populace and between the rural and urban populations (Batchelor et al., 2005). This may imply that there will be increase in the exchange of information in situations such as price surges and scarcity. Chowdhury et al. (2001) asserts that ICTs contributes to a household's food security by reducing the public and private search costs for food. Findings from Lashgarara et al. (2010) indicate that the use of ICTs is improving access to food in rural households and plays a key role in alleviating food insecurity by decreasing the cost to access information. On the contrary, Olaniyi et al. (2016) assessed the correlation between ICT use and food security in Nigeria and found that the use of cell phones and other communication devices did not improve the food security status of households.

**Table 11.** Determinants of Household Accessibility to Seafood by Location using FAI

| Variables | Rural | Urban | Peri-Urban |
|---|---|---|---|
| Electricity | 0.062* (0.036) | 0.009 (0.010) | 0.054***(0.008) |
| Communication | 0.034***(0.008) | 0.021**(0.009) | 0.008 (0.007) |
| Transportation | 0.034 (0.006) | -0.000 (0.006) | -0.014***(0.004) |
| Price of seafood | 0.011 (0.024) | 0.035* (0.019) | 0.024 (0.017) |
| Age | -0.002** (0.001) | 0.002** (0.001) | -0.001 (0.001) |
| Household size | -0.005**(0.002) | -0.001 (0.004) | 0.006**(0.002) |
| Female | -0.032 (0.021) | 0.015 (0.023) | 0.011 (0.016) |
| Married | 0.030 (0.039) | -0.013 (0.035) | 0.044**(0.018) |
| Unpaid employee | 0.041 (0.049) | 0.077* (0.044) | -0.049 (0.032) |
| Paid employee | -0.001 (0.047) | 0.045 (0.031) | 0.008 (0.028) |
| Education | -0.006**(0.003) | 0.000 (0.003) | -0.005***(0.002) |
| Household income | -0.008 (0.006) | 0.002 (0.005) | -0.006 (0.002) |
| Constant | 1.357***(0.075) | 1.016***(0.059) | 1.280***(0.046) |

Note: *** indicates $p < 0.001$, ** $p < 0.05$, and * $p < 0.10$; Robust standard error in parenthesis.

Increases in transportation cost reduces accessibility to seafood in peri-urban households by 0.014% (Table 11). The location of peri-urban households provides increased access to a variety of food outlets because of their proximity to urban areas and markets. Although they are close to urban areas, transportation costs associated with increased search time increases because of travel distance between different food outlets. The expansion of the DART system will help in reducing the cost of transportation for peri urban households. In Malawi, the impact of transportation on food access showed that an increase in the travel distance increased per capita daily calories consumed by urban household (Tembo and Simtowe, 2009). Osebeyo and Aye (2014) also found a negative and significant effect of cost of transportation on market participation for smallholder farmers in Nigeria. Improving transportation infrastructure or reducing the cost of transportation increases the probability of improving the welfare of producing households and consumers since high cost of transportation is translated into high food prices. The growing per capita income of peri-urban populations, expansion in access to electricity, refrigeration systems for food storage and transportation facilities have enhanced the growth of supermarkets in peri-urban areas.

The price of fish impacts access to fish by 0.04% for peri-urban households. Urban households may have increased access to a diverse number of food outlets, which increases their accessibility. Supermarkets are commonly one-stop shops, which provide what consumers need and are located in urban and peri-urban areas. Most studies use increased food prices and so the coefficient is always negative. The number of food outlets a household can visit is determined by their income level and market prices (Sakyi, 2012).

Aside the variables of interest, the age, marital status, employment status and the years of education of the caregiver, and household size also significantly influence the household's accessibility to seafood. For rural households, an increase in age is consistent in reducing access to seafood in the two regressions (Tables 10 and 11). Similarly, an increase in the years of education reduces accessibility to seafood for peri-urban households.

***Comparison of FAC and FAI Estimates***

The differences between estimates from the FAC and FAI models were tested using the chi-squared test. From Table 12, expenditure on communication shows no statistical difference between estimates, but expenditures on transportation and electricity are significantly different at the 1% level. The differences in transportation shows the differences between the estimates because of the differences in the dependent variables. These results show that the FAI is a different measure for access to seafood, though we cannot explicitly say whether the bias is upwards or downwards.

**Table 12.** Testing Differences in Coefficients between Access Count and FAI Estimates

| Variable | Chi sqr. value | P > chi_2 |
|---|---|---|
| Electricity | 51.29 | 0.000 |
| Communication | 2.94 | 0.229 |
| Transportation | 13.36 | 0.001 |

***Policy Recommendations for Tanzania***

1) Studies in the literature on the impact of infrastructure development on the agricultural sector has focused on productivity. However, the outcome of this study also highlights the importance of improving infrastructure in Tanzania, particularly electricity, communication and transportation to improve access to seafood. The DART is a good system that helps to reduce traffic congestion and increase access to seafood and food in general in Tanzania. Continued investments in infrastructure in Tanzania will go a long way to improve seafood accessibility and consequently food security.
2) Access to seafood measures that accounts for the heterogeneous environment may be a better measure than just the access count measure.

## CONCLUSIONS

Fish farming households are more food secure relative to non-fish farming households using the Food Consumption Score as a measure of food security. The decision to adopt fish farming is influenced by the wealth of the household, the agro-ecological zone, residing in a peri-urban area, the household size and per capita income of the household. Female household heads and women in general located particularly in the savannah zone (Northern Ghana) will benefit from adopting fish farming particularly cage farming. There is an associated prospect of declining food insecurity.

The per capita fish consumption in Ghana is one of the highest in Sub Saharan Africa. It is a cheap source of protein and common among low-income and subsistence households. Aside price and income being a determining factor in the demand for fish among households, ethnicity and geographical location have been identified as demand determinants among Ghanaian households. Producers can improve consumer targeting and profits by having knowledge of consumers' ethnicity and location.

Tanzania's fish industry is one of the largest in Sub Saharan Africa in terms of production quantities but per capita consumption is 7.7 kg, lower than the global average (19kg). Non-existent and inefficient infrastructure are known to hinder access and availability to fish locally. Increasing access of the household to electricity and communication networks is positively correlated with improvements in seafood access to fish. In measuring accessibility to seafood, it is more accurate to use a more comprehensive measure, which accounts for the environment that the household is located and the type of food outlets available in their location.

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## LITERATURE CITED

Abdulai, A., and Aubert, D. (2004). A Cross-Section of Household Demand for Food and Nutrients in Tanzania. *Agricultural Economics* 31, 67-79.

Amao, J.O. (2006). Determinants of Protein Consumption among Households in ILA Local Government Area of Osun State, Nigeria. *Middle-East Journal of Scientific Research*, Vol. 15, No. 10, pp. 1014-1010.

Anyanwu, S.O. (2014). Quantitative Analysis of Fish Consumption in Rivers State, Nigeria. *American Journal of Experimental Agriculture*, Vol 4, No.4, pp. 469-475.

Batchelor, S. and Scott, N. (2005). Good Practice Paper on ICTs for Economic Growth and Poverty Reduction. The DAC Journal, Vol. 6, No. 3. Available on www.oecd.org/dac.

Baker, J. (2000). Evaluating the Impacts of Development Projects on Poverty: A Handbook for Practitioners. Washington, D.C.: The World Bank.

Bellemare, F., Lee, Y.N. and Just, D. R. (2017). Producer Attitudes to Output Price Risk: Evidence from the Lab and from the Field.

Birol, E., Asare-Marfo, D., Karandikar, B. and Roy, D. (2011). A Latent Class Approach to Investigating Farmer Demand for Biofortified Staple Food Crops in Developing Countries: The Case of High-Iron Pearl Millet in Maharashtra, India. HarvestPlus Working Paper.

Boomsma, A. (2014). Regression Diagnostics with R. Department of Statistics &Management Theory. University of Groningen.

Chowdhury, N. (2001). Information and Communications Technologies. In: Appropriate Technology for Sustainable Food Security. International Food Policy Research Institute.

Essuman, K.M. (1990). A Study on Processing, Marketing and Consumption of Cured Fish in West Africa: Fermented Fish in Africa. FAO Fisheries Technical Report, No. 329.

Food and Agriculture Organization – FAO. (2006). Food Security. Policy Brief (June).

Food and Agriculture Organization – FAO. (2002a). The State of Food Insecurity in the World 2001. Rome.

Food and Agriculture Organization - FAO. (2002b). Diet, Nutrition and the Prevention of Chronic Diseases. WHO Technical Report Series, 916.

Ham, S. and Yang, I-S. (1998). Modelling U.S. Household Expenditure on Food AWAY from Home (FAFH): Logit Regression Analysis. *Journal of Hospitality & Tourism Research*, Vol. 22, No. 1, pp. 15-24.

Heinbuch, U. 1994. Animal Protein Sources for Rural and Urban Populations in Ghana. Programme for integrated Development of Artisanal Fisheries in West Africa. Technical Report No. 58.

Hoddinott, J. and Yohannes, Y. (2002). Dietary Diversity as a Food Security Indicator. Food and Nutrition Technical Assistance Project (FANTA).

Jensen, R.T. and Miller, N. (2011). Do Consumer Price Subsidies Really Improve Nutrition. *The Review of Economics and Statistics*, Vol. 93, No. 4, pp. 1205-1223.

Kennedy, G., A. Berardo, C. Papavero, P. Horjus, T. Ballard, MC. Dop, J. Delbaere and D. Brower. (2010.) Proxy Measures of Household Food Consumption for Food Security Assessment and Surveillance: Comparison of eth Household Dietary Diversity and Food Consumption Scores. *Public Health Nutritio*n 13(12), 2010-2018.

Lajous, M., Willet, W.C., Robins, J., Young, J.G., Rimm, E., Mozaffarian, D. and Hernan, M. A. 2012. Changes in Consumption in Midlife and the Risk of Coronary Heart Disease. *American Journal of Epidemiology*, Vol. 178, No. 3, DOI: 10.1093/aje/kws478.

Larochelle, C., and Alwang, J. (2014). Impacts of Improved Bean Varieties on Food Security in Rwanda. Selected Paper for the Annual Economist Meeting Annual Meeting, Minneapolis. July 2014.

Lashgarara, F., Mirdamadi , S. M., and Hosseini , S. J. (2012). Role of ICTs in Improving Food Accessibility of Iran's Rural Households. *Annals of Biological Research*, pp.73-80.

Lee, H. and Tan, A. (2006). Determinants of Malaysian Household Expenditures of Food-Away-From-Home. Contributed paper presented at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006.

MacKinnon, J.G. and Magee, L. (1990). Transforming the Dependent Variable in Regression Models. *International Economic Review*, pp.315-339.

Olaniyi, O.A., Olumuyiwa, A. and Ismaila, K.O. (2016). Information and Communication Technologies (ICTs) Usage and Household Food Security Status of Maize Crop Farmers in Ondo State, Nigeria: Implication for Sustainable Development. Library Philosophy and Practice (e-Journal). 1446. Available at hyyp://digitalcommons.unl.edu/libphilprac/1446.

Osebeyo, S.O. and Aye, G.C. (2014). Transaction Costs and Marketing Decision: A Case Study of Smallholder Tomato Farmers in Makurdi, Nigeria. *Urban, Planning and Transport Research*, Vol. 2, No. 1, pp. 333-340. DOI:10.1080/21650020.2014.939296.

Osei-Asare, Y.B. and Eghan, M. 2014. MEAT Consumption in Ghana, Evidence form Household Micro-Data. *The Empirical Economic Letters*, Vol. 13, No. 2.

Plataroti, L. (2016). What is the Impact of Gendered Headship on Food and Nutrition Security in the Breadbasket of Tanzania? An Investigation on Cross-Sectional Data in Rural Tanzania. Wageningen University and Research, Development Economics Group.

Sakyi, P. (2012). Determinants of Food Accessibility of Rural Households in the Limpopo Province, South Africa. Master's Dissertation. Ghent University.

SAS Institute Inc. (1999). SAS OnlineDoc, Version 8, Cary, NC: SAS Institute Inc., 1999.

Sui, Z., Raubenheimer, D., Cunningham, J. and Rangan, A. 2016. Changes in Meat/Poultry/Fish Consumption in Australia: From 1995 to 2011-2012. *Nutrients*, 8, 753; doi: 10.3390/nu8120753

Tambi, E.E. 2001. Analysis of Household Attitudes toward the Purchase of Livestock Products and Fish in Cameroon. *Agricultural Economics*, 26, 135-147.

Tembo, D., and Simtowe, F. (2009). The effects of market accessibility on household food security: Evidence from Malawi. In Conference on International Research on Food Security, Natural Resource Management and Rural Development (pp. 6-8).

Temu, A. E., Nyange, D., and Kashasha, L. K. (2005). Assessing Rural Services, Infrastructure and their Impact on Agricultural Production, Marketing and Food Security in Tanzania. Final Donor Report, IFPRI Eastern African 2020 Vision Network.

Van Crowder, L. and Fortier, F. 2000. National Agricultural and Rural Knowledge and Information System (NARKIS), a proposed Component of the Uganda National Agricultural Advisory Service (NAADS).

WorldFish Center, (2009). Fish Supply and Food Security for Africa. Available at www.thefishsite.com/articles/1946/aquaculture-and-food-security-poverty-alleviation-and-nutrition-in-ghana.

World Food Programme - WFP. (2009). Emergency Food Security Assessment Manual. Rome.

Wurtz, A.M.L., Hansen, M.D., Tjonneland, A., Rimm, E.B., Schmidt, E.B., Overad, K. and Jakobsen, M.U. 2016. Substitutions of Red meat, Poultry and Fish and Risk of Myocardial Infarction. *British Journal of Nutrition*, 115, 1571-1578.