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Effect of the economic food environment on consumer food choice in selected areas of Tanzania: Price elasticities of demand for food groups

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Abstract

This study uses the censored quadratic almost ideal demand system (QUAIDS) to estimate Marshallian own- and cross-price elasticities for six food groups. The elasticities are used to examine how households in selected districts of Tanzania respond to price changes, utilising cross-sectional data from 549 randomly sampled households. The findings show that all food groups have strong negative responses to price changes. Cross-price elasticities reveal both substitution and complementarity. Starchy foods have a complementary relationship with all other food groups, reflecting common dietary patterns. Substitution occurs between starches and legumes, animal-source foods and starches, and starches and oils and fats. Households substitute starches for legumes when starchy food prices rise, suggesting a trade-off between carbohydrates and proteins. These findings indicate that food price interventions, including producer subsidies, import tariff exemptions and incentives for healthier foods, can encourage healthier diets. Integrating food prices into nutrition-sensitive agricultural programmes may improve access to nutritious foods.

Key words: food environment, food choice, food group price elasticity, malnutrition, Tanzania

1. Introduction

Changes in the economic food environment have emerged as a salient concern due to their role in shaping consumer food choice behaviour. This concern stems from the increasing prevalence of malnutrition – in all forms – and diet-related non-communicable diseases (NCDs), both of which are largely linked to consumer choice behaviour. Although all countries are affected by at least one form of malnutrition, low- and middle-income countries (LMICs), including Tanzania, often bear a disproportionate burden. These countries are experiencing the co-existence of undernutrition, widespread micronutrient deficiencies, and the growing prevalence of overweight, obesity and NCDs (FAO *et al*. 2023, 2014). Addressing these nutritional challenges requires, among other factors, a clear understanding of how consumers make food choices, along with the underlying factors, particularly within the economic food environment framework.

Affordability, a central component of the economic food environment, plays a dominant role in determining access to a healthy diet, particularly in LMICs (Gouel & Guimbard 2019; Constantinides *et al*. 2021). Globally, approximately 36% of the population cannot afford nutritious food, underscoring the role of affordability in accessing healthy diets (Ritchie & Rosado 2021; Masters *et al*. 2024). While food affordability is determined primarily by household income and food prices (Chen & Yang 2014; Herforth & Ahmad 2015), this study specifically focuses on food prices as a key mechanism through which the economic food environment shapes consumer food choices.

Food prices are inherently volatile and are influenced by a range of factors, including seasonality, climate shocks, global economic instability, public health crises such as the COVID-19 pandemic, and geopolitical crises (García-Germán *et al*. 2016; Mtingile & O'Connor 2019; Ceballos *et al*. 2021). Such fluctuations can alter not only the types of foods households purchase but also the frequency and quantities of their purchases, thereby influencing dietary patterns. In LMICs such as Tanzania, where households often allocate a substantial share of their income to food, food price volatility may constitute a significant constraint to achieving adequate and balanced diets. Understanding how consumers adjust their food consumption in response to price changes is therefore essential for informing policies aimed at addressing malnutrition. One of the most widely used measures for analysing such behavioural responses is the price elasticity of demand, which quantifies the extent to which food consumption changes in response to variations in food prices.

Several studies have investigated the price elasticity of food demand in Tanzania, as well as in other contexts. Although their findings vary, the evidence generally suggests that food demand responds to price changes. For instance, Ecker and Qaim (2011) and Weliwita *et al*. (2011) reported relatively low own-price elasticities for staple foods such as rice and maize in Malawi and Tanzania, respectively. This indicates that the demand for maize and rice is less sensitive to price changes. In contrast, García-Germán *et al*. (2016) found that increases in maize prices were associated with higher levels of adult undernutrition in Tanzania, implying a greater sensitivity to price fluctuations. Furthermore, Kweka (2023) estimated the price elasticities of demand for a range of food categories, including starches, cereals, fruits and vegetables, and reported mixed findings.

However, most of these studies have focused on estimating price elasticities for individual food items rather than for broader food groups. Given that food items within the same group often serve similar nutritional functions, analyses that exclude interactions across food groups may have limited relevance for nutrition policy recommendations. Furthermore, the majority of existing studies report food price elasticities without examining the implications of demand responses for dietary diversity and quality. Consequently, empirical evidence remains limited regarding the extent to which consumers substitute between food groups, particularly among those constituting a healthy diet. In addition, there is insufficient understanding of which food groups are highly price-sensitive, and which are relatively unresponsive to price changes.

Therefore, this study aims to examine how consumers make food choices across the six food groups that constitute a healthy diet according to the Tanzania Food-Based Dietary Guidelines (FBDGs) (United Republic of Tanzania (URT), 2023). Specifically, the study estimates: (a) the own-price elasticities of demand for the food groups and (b) the cross-price elasticities of demand among food groups. The findings are anticipated to offer important insights to inform policymakers in designing and prioritising nutrition-sensitive interventions to reduce malnutrition and diet-related NCDs. The remainder of the paper is organised as follows. Section 2 presents the conceptual framework, while Section 3 details the methodology. Section 4 discusses the empirical findings, and Section 5 concludes the paper by presenting the study's conclusions, policy recommendations, and limitations.

2. Conceptual framework

The conceptual framework of this study draws from the sustainable food system framework of the HLPE (2017) and the food environment framework of Turner *et al*. (2018). As depicted in Figure 1, the household operates within a larger food system that includes key elements such as the food environment, food supply chains, and political, demographic and socio-cultural factors that interact with one another. The interaction of the food environment with other components of the food system influences household food choices, including where, what and how food is acquired and prepared. These choices, in turn, affect dietary quality and diversity, ultimately determining nutritional and health outcomes. Although the food environment encompasses various dimensions, this study focuses on the pathways linking food prices and household food choices to their implications for diet quality, diversity and nutrition.

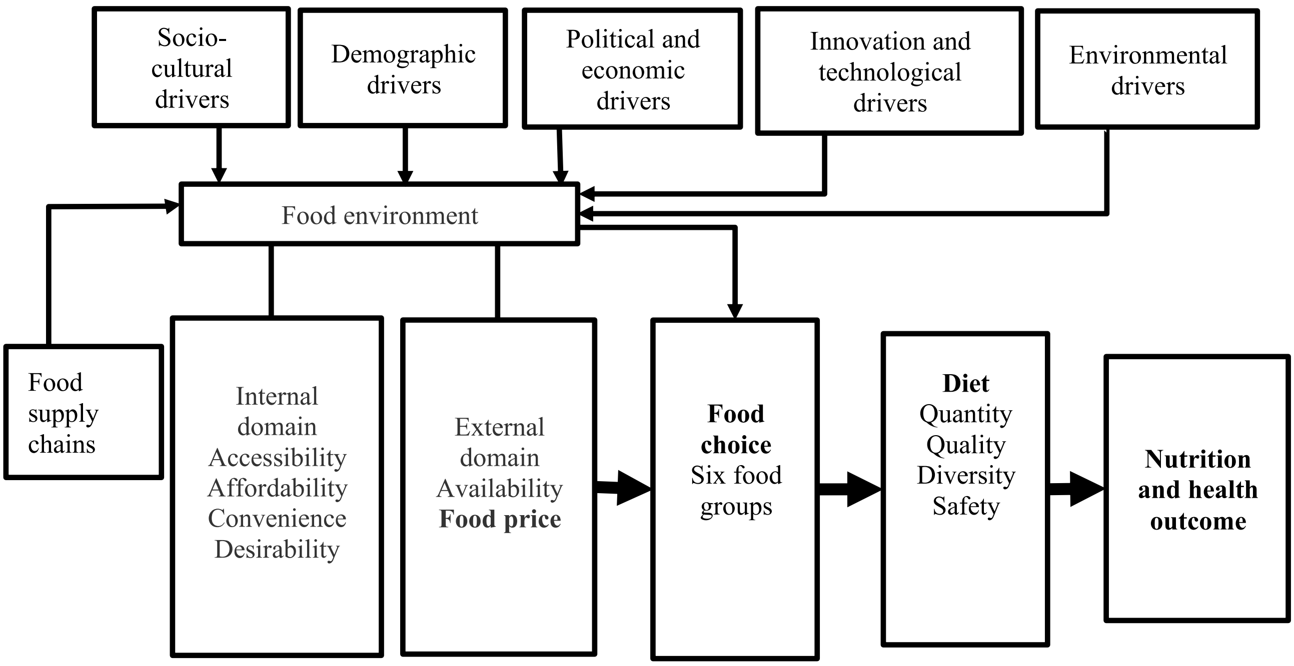

Figure 1: Conceptual framework

Consistent with the conceptual framework emphasising food prices in shaping household food choices and nutritional outcomes, this study employs the censored quaids model developed by Poi (2012) to quantify these relationships. Estimating demand responses to price changes is complicated by zero consumption of some food groups, which may bias the results if unaddressed. The censored quaids appropriately accounts for such censoring while providing reliable own- and cross-price elasticity estimates. These elasticities capture household consumption adjustments due to food price changes, providing empirical evidence of the framework's price–choice–nutrition pathway. Integrating the model with a food-system perspective links conceptual insights with econometric evidence on how food prices influence dietary quality and nutrition. The findings can inform policies, such as taxing unhealthy foods and subsidising nutritious alternatives, as well as nutrition-sensitive agricultural programmes that promote healthier food production, improve availability, and potentially reduce market prices.

3. Methodology

3.1 Area of study

This study was conducted in Ilala and Mkuranga districts, located in Tanzania's coastal zone within the Dar es Salaam and Pwani regions, respectively (Figure 2). Ilala, with a population of 1 649 912 people, is the centre of Dar es Salaam city, where manufacturing, retail, hospitality, banking and urban agriculture dominate, making it a major consumption hub. In contrast, Mkuranga, with a population of 533 033 people (URT 2022), represents a predominantly rural setting where agriculture, including crop farming, fishing and livestock keeping, is the main economic activity. Major crops include cashew nuts, cassava, coconuts, sesame, vegetables and fruits. Approximately 72% of its population lives in rural areas, and the URT (2024) classifies the district council as a rural local government authority. Both districts share similar agroecological conditions, including approximately 1 000 mm annual rainfall and temperatures of 27°C to 29°C (URT 2024), but their contrasting economic environments may shape household food choices differently.

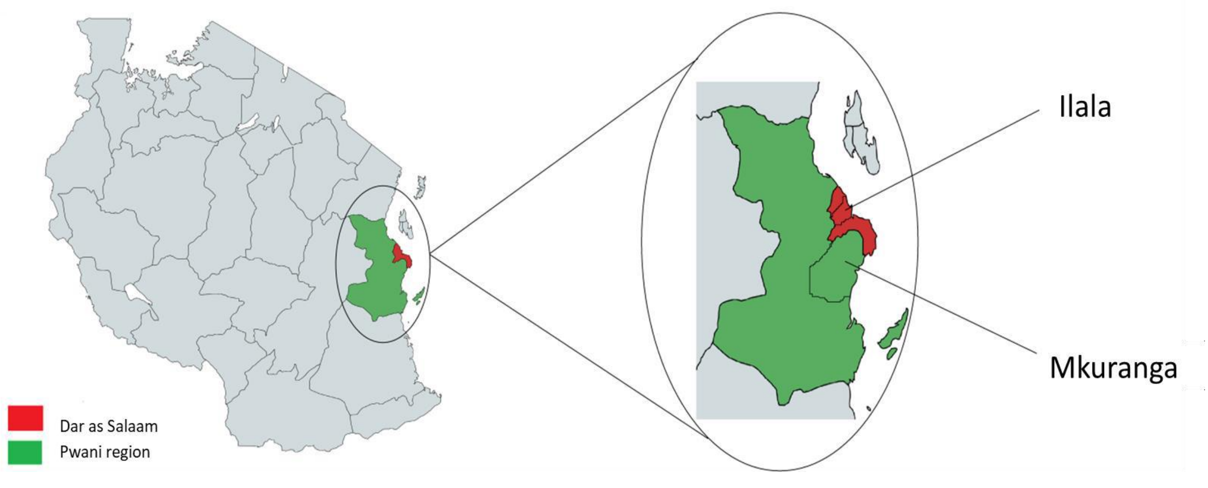

Figure 2: Study areas
Source: Mushi *et al.* (2025)

3.2 Sampling procedures and data collection

This study forms part of the FoCo-Active project, which examines food consumption patterns and physical activity among primary school children and their parents. The sample size for this study was determined using a formula introduced by Yamane (1967) (Equation (1)). A pupil-to-parent sampling approach was employed to identify households with children aged eight to 11 years, facilitating matching between children and their parents. Following Magnani's (1997) sampling procedures, a five-stage stratified sampling design was used to select the sample. The first stage involved purposively selecting the study sites within the Dar es Salaam and Pwani regions.

$$n = \frac{N}{1+N(e)^2}, \tag{1}$$

where n represents the required minimum sample size, N is the population of interest, and e is the error term. The population of interest was 3 970 households and the margin of error used was 0.05. An additional 50% of the desired sample size was included in the final sample size to accommodate potential attrition. This resulted in 545 households, which was rounded up to 550 – 413 from Ilala district and 137 from Mkuranga district.

In the second stage, wards were purposively selected within each stratum. Gongolamboto, Upanga and Kinyerezi wards were selected from Ilala district to represent low-, middle- and high-socioeconomic status (SES) urban groups, while Mkamba and Kisegese wards were selected from Mkuranga district to reflect typical rural Tanzanian communities. In the third stage, eight primary schools were purposively selected, with two schools from each selected Ilala ward and one from each Mkuranga ward. In the fourth stage, pupils were randomly selected from the participating schools, with sample sizes proportionally allocated across schools. Finally, the households of the selected pupils were contacted and surveyed. After data cleaning, 549 households constituted the final analytical sample.

The analysis uses cross-sectional data collected through a structured questionnaire in February and March 2023. The data include weekly household food and non-food expenditures, frequently consumed foods across six food groups based on a seven-day recall period, quantities purchased weekly, and food prices. The six food groups specified in Tanzania Mainland's FBDG are: (i) vegetables, (ii) fruits, (iii) cereals, starchy roots, plantains and green bananas, (iv) animal-source foods, (v) healthy fats and oils and (vi) legumes, nuts and oily seeds. Because milk differed in measurement units from other animal-source foods, it was analysed separately, while the remaining animal-source foods were classified as meat and fish. Unit values were used as proxies for food prices, while a market survey verified actual prices to minimise potential measurement bias.

3.3 Theoretical and analytical frameworks

This study is grounded in the theory of consumer choice (Nicholson & Snyder 2008; Mankiw 2012), which posits that consumers face unlimited needs but are constrained by limited resources, requiring them to make decisions about which needs to satisfy and which to forgo. The theory examines how consumers trade off alternative needs to attain the highest utility possible given their limited budget. Thus, when presented with total income M, and food choice alternatives, say j and k, the consumer i will choose j over k if:

$$U_{ijt} > U_{ikt} \quad \text{for all} \quad j \neq k; \text{ given that } M = JP_j = KP_k, \tag{2}$$

where U_{ijt} and U_{ikt} are assumed to be unobservable utilities that a consumer can derive from consuming food j and k, respectively; J and K are quantities of food j and k, and P_j and P_k are their prices, respectively. For consumers to make rational choices and maximise utility, it is assumed that consumer preferences satisfy the axioms of completeness, monotonicity, diminishing marginal rate of substitution, and continuity (Mankiw 2012; Nicholson & Snyder 2008). Consistent with this study's conceptual framework, consumers may face financial constraints that limit economic access to all food groups and desired quantities. Consequently, food prices are expected to influence consumption decisions. According to Mankiw (2012), price changes affect consumer choices through income and substitution effects, influencing both the selection of food groups and quantities consumed. These adjustments in food consumption, in turn, may affect household dietary quality and nutritional outcomes.

Drawing on consumer choice theory, quaids was employed to estimate food-group price elasticities. Quaids extends the almost ideal demand system (AIDS), developed by Deaton and Muellbauer (1980), and is preferred because it accommodates greater flexibility in consumer preferences, controls for endogeneity and censoring, and remains consistent with consumer demand theory, thereby reducing potential estimation bias (Banks *et al*. 1997; Ecker & Qaim 2011). Notably, quaids typically uses data on food consumed at home. Previous studies, including García-Germán *et al*. (2016), Ecker and Qaim (2018), Ecker and Comstock (2021) and Kweka (2023), have applied quaids to estimate price elasticities.

Following Poi's (2012) procedures, estimating the Marshallian (uncompensated) price elasticities of demand involves two stages, which assume a weak separability between food and non-food consumption (Banks *et al*. 1997). The first stage involves estimating the total food demand (Equation (3)) against the total demand for non-food consumption using the Working-Leser (WL) model (Working 1943; Leser 1963).

$$S_h^f = \alpha_0 + \beta ln m_h + \gamma ln p_h^f + Z_h'\Psi + \varepsilon_h, \tag{3}$$

where S_h^f is the household's budget share spent on food; m_h is the household total expenditure, a proxy for household income; and p_h^f stands for the average food price. The vector Z_h represents the household demographic characteristics as control variables that can influence food choices. Contributing to the majority of previous studies (Weliwita *et al*., 2011; García-Germán *et al*. 2016) that have mainly used the sex, age and education of the household head, and household size as control variables, the present study adds to the model. This addition includes the socio-economic status of the household, along with spatial location (rural or urban), as variables other than food price that may potentially influence consumer food choices.

The second stage involves estimating quaids. This is a system of food budget share equations for each good group. According to Banks *et al*. (1997), quaids follows the indirect random utility theory, which is given as:

$$\ln V(p,m) = \left[\left\{\frac{\ln m - \ln a(p)}{b(p)}\right\}^{-1} + \lambda(p)\right]^{-1}, \tag{4}$$

where m is the total food expenditure, and $ln a(p)$, $b(p)$ and $\lambda(p)$ represent a vector of prices. The function $\ln a(p)$ has a transcendental logarithmic form, which is given as:

$$\ln a(p) = \alpha_0 + \sum_{i=1}^{k=6} \alpha_1 \ln p_1 + \frac{1}{2}\sum_{i=1}^{k=6}\sum_{j=1}^{k=6} \gamma_{ij} \ln p_i \ln p_k, \tag{5}$$

where k represents the number of food groups in a demand system (in this study, six food groups), and i and j are the food groups with their prices P_i and P_j, respectively.

The functions $b(p)$ (a Cobb-Douglas price aggregator) and $\lambda(p)$ (Equation (4)) are given respectively as:

$$b(p) = \prod_{i=1}^{k=6} p_i^{\beta_i} \qquad \text{and} \qquad \lambda(p) = \sum_{i=1}^{k=6} \lambda_i \ln p_i$$

From the demand theory, the parameters α_i, γ_{ij}, β_i and λ_i, which are to be estimated for the quaids model, need to meet the conditions of homogeneity of degree one on price and income, adding up, and the Slutsky symmetry, as given below:

$$\sum_{i=1}^{k=6} \alpha_i = 1\,; \sum_{i=1}^{k=6} \beta_i = 0\,; \sum_{i=1}^{k=6} \lambda_i = 0\,; \sum_{i=1}^{k=6} \gamma_{ij} = 0\,; \sum_{i=1}^{k=10} \gamma_{ji} = 0;\ \text{and}\ \gamma_{ij} = \gamma_{ji}$$

Let us suppose that the quantity of the food group i is given as q_i, and its price is given as p_i. The household expenditure shares for the food group i will be given as $\frac{q_i p_i}{m}$. Applying Roy's identity to the indirect utility function (Equation (4)), the expenditure share equation for the food group i in the quaids can be given as:

$$w_i = \alpha_i + \gamma_{ij} \ln p_j + \beta_i \ln\left\{\frac{m}{a(p)}\right\} + \frac{\lambda_i}{b(p)} [\ln\{\frac{m}{a(p)}\}]^2\,; \qquad \text{for } i = 1, \ldots, k \tag{6}$$

Incorporating demographic characteristics (z) as control variables that may influence the household's food choice, the quaids equation for good i is modified to:

$$w_i = \alpha_i + \sum_{i=1}^{k=10} \gamma_{ij} \ln p_j + (\beta_i + \eta_i' z) \ln\left\{\frac{m}{\overline{m}_0(z) b(p)}\right\} + \frac{\lambda_i}{b(p) c(p,z)} \left[\ln\left\{\frac{m}{\overline{m}_0(z) a(p)}\right\}\right]^2, \tag{7}$$

where $\overline{m}_0(z)$, defined as $\overline{m}_0(z) = 1 + p'z$, is a measure of a household's food expenditure as a function of demographics; and $c(p, z)$ controls for changes in relative food prices and actual food consumption.

Since there are six food groups under consideration in this study, it is likely that some households may not always have access to all food groups for an entire week. As such, there would be a record of zero consumption of some food groups in some households, resulting in censored data on the dependent variable, which subjects the estimation to bias. To address this problem, Shonkwiler and Yen (1999) propose two steps: using multivariate binary models to determine the propensity of consuming food from a particular food group, and modelling the food quantity consumed from the chosen groups.

The estimates of the multivariate probit regression provide the univariate standard normal probability density function, $\phi(\hat{\tau}_i' z)$, and the cumulative distribution function, $\delta_i \varphi(\hat{\tau}_i' z)$, which are combined with Equation (7) to provide a latent budget share of food group (Equation (8)).

$$w_i = \phi(\hat{\tau}_i' z) w_i + \delta_i \varphi(\hat{\tau}_i' z) + \xi_i \tag{8}$$

The final quaids equation that incorporates the demographic variables and addresses the censored data problem is given as:

$$w_i = \phi(\hat{\tau}_i'z)\left[\alpha_i + \sum_{i=1}^{k=10}\gamma_{ij}\ln p_j + (\beta_i + \eta_i'z)\ln\left\{\frac{m}{\overline{m}_0(z)b(p)}\right\} + \frac{\lambda_i}{b(p)c(p,z)}\left[\ln\left\{\frac{m}{\overline{m}_0(z)a(p)}\right\}\right]^2\right] + \delta_i\varphi(\hat{\tau}_i'z) \quad (9)$$

The uncompensated (Marshallian) price elasticities of demand can be obtained by taking the first-order condition (FOC) of the censored quaids equation with respect to the price of a particular food group (Equation (10)).

$$\frac{\partial w_i}{\partial \ln p_j} = \frac{1}{w_i} + \left(\gamma_{ij} - \left[\beta_i + \eta_i'z + \frac{2\lambda_i}{b(p)c(p,z)}\ln\left\{\frac{m}{\overline{m}_0(z)b(p)}\right\}\right] * \left(\alpha_j + \sum_{i=1}^{k}\gamma_{ji}\ln p_i\right) - \frac{(\beta_j+\eta_i'z)\lambda_i}{b(p)c(p,z)}\left[\ln\left\{\frac{m}{\overline{m}_0(z)a(p)}\right\}\right]^2\right)\phi(\hat{\tau}_i'z) + \varphi_i\tau_{ij}\left(1 - \frac{\delta_i}{w_i}\right) - \delta_{ij} \quad (10)$$

In addition, descriptive statistics and principal component analysis (PCA) were employed to assess household characteristics and socioeconomic status. PCA reduces data dimensionality by transforming correlated variables into a smaller set of components (Vyas & Kumaranayake 2006; Vieira *et al*. 2022). In this study, the socioeconomic status (SES) index was constructed using monthly median income, employment status, education, toilet type, food poverty, primary water source, housing and refrigerator ownership, weekly food expenditure, total monthly expenditure, household illiteracy, and formal and informal employment. Continuous variables, including income and expenditure, were entered in their original form, while categorical variables were converted into dummy variables. The coding of each variable used in the PCA is provided in Appendix 1.

Since these variables are measured on different scales, they were standardised into z-scores so that they have a mean of 0 and a standard deviation of 1, as shown in Equation (11).

$$Z_{ij} = \frac{X_{ij} - \overline{X}_{ij}}{SD_{ij}}, \quad (11)$$

where Z_{ij} is the standardised value for the j-th variable of household i, X_{ij} is the observed value of the variable, and $\overline{X}_{ij}$ and SD_{ij} are the mean and standard deviation of the variable j, respectively.

The standardised variables were subjected to PCA to derive principal components, which are linear combinations that explain maximum variation in the data. As shown in Equation (12), each component was calculated as a weighted sum of standardised variables and may take positive or negative value. The first principal component, explaining the largest proportion of variation in socioeconomic characteristics, was retained as the socioeconomic status (SES) index.

$$PC_{1i} = \sum_{j=1}^{n} Z_{ij}w_j = SES\ Index_i, \quad (12)$$

where PC_{1i} is the first principal component for the household i, w_j is the weight (loading) of the individual variable j, n is the number of variables used, and $SES\ Index_i$ is the socioeconomic status of the household i, whose scores are used to group households into various status groups. This study used tertiles of $SES\ Index_i$ values to categorise households into low, middle and high status.

4. Results and discussion

4.1 Characteristics of households

Table 1 presents the demographic and socio-economic characteristics of the households involved in this study. The table shows that, among the surveyed households, 81% are male-headed, with an average age of 43. About 31% of these household heads have an education level of at least secondary school, close to the country's average of 33% as reported by the URT (2022). The majority (60%) of households with high socio-economic status (SES) have attained at least a secondary education, in contrast to low SES households, whose majority (99%) have below a secondary education level. Similarly, urban households have a higher education level than their rural counterparts. The average household size is 5.6, which exceeds the national average of 4.5 (URT 2022). This could be attributed to the high fertility rate and in-migration to the study areas. Household size may influence food expenditure, as larger households are likely to spend more on food than smaller households. To address this, the food expenditure pattern employed per capita expenditure to capture the average expenditure of each member of the household.

Table 1: Descriptive statistics for the households' characteristics

	Mean, proportions (std. error)					
Variable	**Pooled mean/ proportion**	**Rural**	**Urban**	**Low SES (40%)**	**Middle SES (20%)**	**High SES (40%)**
Household size (number)	5.59	6.4 (0.2)	5.33 (0.1)	5.8 (0.15)	5.2 (0.21)	5.5 (0.05)
Household head sex (1 = male)	0.81	0.82 (0.03)	0.81 (0.02)	0.74 (0.03)	0.80 (0.04)	0.88 (0.02)
Household head age (years)	42.94	44.63 (0.9)	42.38 (0.5)	44.07 (0.7)	40.98 (0.9)	42.75 (0.6)
Household head education (1 = secondary and above)	0.31	0.08 (0.02)	0.38 (0.02)	0.05 (0.02)	0.22 (0.04)	0.60 (0.03)

4.2 Average food group prices in the study areas

Table 2 presents average food prices across the study areas, with per-kilogram values in USD equivalents of TZS shown in parentheses. Meat and fish are the most expensive food group, averaging TZS 8 332.11 (USD 3.2) per kilogram. This is consistent with Kweka (2023), who reported similar findings using the Tanzania National Panel Survey 2012–2015. A statistically significant ($p < 0.05$) price difference of TZS 789.02 (USD 0.3) per kilogram exists between rural and urban areas, with higher prices in urban areas. This suggests that low-income households may face limited access to meat and fish, potentially restricting their intake of high-quality animal-source proteins and increasing vulnerability to undernutrition, particularly among children under five. Policies aimed at reducing prices and improving the affordability of these foods could enhance access to animal-source proteins and contribute to efforts to address malnutrition.

Vegetables represent the most affordable food group, with an average price of 1 142.97 TZS (0.4 USD) per kilogram. There is no statistically significant difference in vegetable prices between rural and urban areas. This relatively low cost may be attributed to the year-round production possibilities of vegetables in both settings. Fruit constitute the second least expensive food group, with an average price of TZS 2 051.14 (0.8 USD) per kilogram. There is a statistically significant difference ($p < 0.05$) between rural and urban prices, with an urban average price of TZS 2 173.25 (8.8 USD) per kilogram – exceeding the rural average by TZS 496.58 (0.2 USD) per kilogram. This price differential may be attributed to the predominantly rural production of fruit, which increases transportation costs associated with supplying to the urban markets. Consequently, fruit tend to be more expensive in urban areas than in rural areas. In addition, the fruit commonly consumed in Tanzania, such as mangoes, oranges and avocados, are tree fruits. The cultivation of these fruits usually requires larger areas of land, which are often scarce in urban settings. This limits urban fruit production, which may contribute to higher urban prices.

Despite their importance as primary sources of essential micronutrients, as suggested by the HLPE (2017), the FAO (2024) has reported that the consumption of vegetables and fruit remains low. Given their relatively low prices in the study area, promoting their nutritional value through initiatives such as food and nutrition literacy programmes may enhance their consumption. Previous studies, including Fernandez *et al*. (2019), show that a consumer's food literacy is associated with diet quality, implying that higher levels of food literacy predict the likelihood of making healthier food choices. Legumes and nuts, another essential component of a healthy diet, are priced at an average of TZS 3 490.27 (1.2 USD) per kilogram, making them the third most expensive food group after oils and fats. Urban prices of legumes and nuts exceed rural prices by TZS 612.83 (0.2 USD) per kilogram, and this difference is statistically significant at $p < 0.05$.

The price of milk (an animal-source food) shares a similar pattern with the prices of cereals, roots and other starches. The results in Table 2 indicate that these foods have significantly higher ($p < 0.05$) prices in urban areas than in rural areas. Furthermore, notable findings were observed regarding oils and fats. Unlike other food groups, which generally have higher average prices in urban areas than in rural ones, the opposite pattern is observed for the oil and fats food group. This can be attributed to transportation and logistics costs, as edible oils and fats are largely manufactured industrially. According to the URT (2016), 50% of edible oil in Tanzania is imported; thus, it requires relatively longer transport logistics to reach the rural areas. This aligns with the findings of Herforth *et al*. (2022), who identified market access and remoteness as likely key determinants of food price patterns in Tanzania. Although many types of oils and fats are regarded as unhealthy, Tanzania's FBDG identifies vegetable oils as the healthier option. Thus, the observed rural-urban consumption pattern of oils and fats may not necessarily be considered unhealthy if the consumption is of vegetable oils.

4.3 Own and cross-price elasticities of demand for food groups

Table 3 reports the uncompensated price elasticities of demand. All food groups exhibit negative own-price elasticities, indicating they are normal goods whose demand increases by less than 1% as prices decline by 1%. Legumes and nuts, meat and fish, fruits and milk exhibit elastic demand, with demand increasing by more than 1% in response to a 1% increase in their prices. This suggests that price reductions can stimulate demand. Except for fruits, these groups have high prices, indicating greater sensitivity to price changes. Rising food prices may reduce access to protein and micronutrients, increasing risks of undernourishment. Food price stability is important for improving nutritional outcomes. Other food groups exhibit inelastic demand, with elasticities ranging between 0.7 and 0.9. Although previous studies report varying own-price elasticities, their findings generally support the present results (Weliwita *et al*. 2011; Me-Nsope & Staatz 2016; Clements & Si 2016). Also, Lokuge *et al*. (2019) identified meat as the most expensive and price-elastic food group in Sri Lanka. These findings demonstrate the influence of food prices on consumption and nutritional outcomes. Rising prices may reduce household consumption and dietary quality, particularly for staple foods. Consistent with this, García-Germán *et al*. (2016) found that higher maize prices increased undernutrition in Tanzania. Thus, food pricing policies can influence the consumption of healthy food and help address malnutrition.

Table 2: Average food group prices between rural and urban households

Food groups and selected foods	Prices in TZS (USD)[1]				Std. error	t-statistic
	Pooled	Urban	Rural	Difference		
Cereals, roots, and other starches	2 231.53 (0.9)	2 329.52 (0.9)	1 931.04 (0.7)	-398.4 (-0.2)	64.69	-6.16***
Legumes and nuts	3 490.27 (1.3)	3 640.96 (1.4)	3 028.18 (1.2)	-612.8 (-0.2)	120.99	-5.06***
Animal and animal products	8 332.11 (3.2)	8 526.13 (3.3)	7 737.11 (3.0)	-789.2 (-0.3)	325.21	- 2.43**
Fruits	2 051.14 (0.8)	2 173.25 (0.8)	1 676.67 (0.6)	-496.6 (-0.2)	196.66	-2.53**
Vegetables	1 142.97 (0.4)	1 191.41 (0.5)	994.43 (0.4)	-197 (-0.1)	126.82	-1.55
Oils and fats	4 829.71 (1.9)	4 693.38 (1.8)	5 247.78 (2.0)	554.4 (0.2)	100.38	5.52***
Milk[2]	2 055.88 (0.8)	2 154.31 (0.8)	1 754.01 (0.7)	-400.3 (-0.2)	54.76	-7.30**

Notes: Mean difference = mean (rural) - mean (urban); ***, ** and * are $p < 0.01$, $p < 0.05$ and $p < 0.1$, respectively; Observations = 549 households.

Table 3: Own and cross-price elasticities of demand for food groups

Quantity demanded for food groups	Price changes						
	Cereals, roots and other starches	Legumes and nuts	Meat and fish	Fruits	Vegetables	Oils and fats	Milk
Cereals, roots and other starches	-0.76	-0.18	-0.04	-0.13	-0.31	-0.31	-0.11
Legumes and nuts	0.14	-1.17	-0.12	0.05	0.0001	-0.51	0.05
Meat and fish	0.01	-0.09	-1.04	-0.15	-0.004	-0.28	-0.42
Fruits	0.09	-0.01	-0.11	-1.00	-0.11	-0.44	-0.02
Vegetables	-0.12	-0.01	-0.02	-0.20	-0.87	-0.26	-0.26
Oils and fats	0.13	-0.26	0.03	-0.18	0.20	-0.93	-0.55
Milk	0.16	-0.05	-0.11	0.02	-0.09	-0.01	-1.39

Table 3 presents the estimated cross-price elasticities of demand among food groups. These elasticities are smaller in magnitude than the corresponding own-price elasticities, indicating that changes in the price of one food group have relatively limited effects on the demand for others. This finding is consistent with studies conducted in Tanzania and Australia (Weliwita *et al*. 2003; Clements & Si 2016). The results reveal both complementary and substitution relationships among food groups. Cereals, roots and other starches (starchy foods) exhibit a complementary relationship with all other food groups. Holding own-food group price and household income constant, a 1% increase in the prices of legumes, meat and fish, fruits, vegetables, oils and fats, and milk reduces the quantity demanded of starchy foods by 0.18%, 0.04%, 0.13%, 0.31%, 0.31%, and 0.11%, respectively.

These results suggest that starchy foods are commonly consumed alongside these food groups. This pattern reflects typical Tanzanian diets, in which staple foods such as maize, cassava and potatoes are frequently consumed with fish, meat, vegetables, fruits and legumes. This is congruent with the studies conducted by García-Germán *et al*. (2016) and Weliwita *et al*. (2003) in Tanzania. However, some studies, including Clements and Si (2016) and Lokuge *et al*. (2019), have reported a substitution

[1] Conversions are based on the mean exchange rates published by the Central Bank of Tanzania (BoT) on 5 June 2026. Retrieved from https://www.bot.go.tz/ExchangeRate/excRates

[2] Milk was categorised separately, not as an independent food group, but as an animal product due to its measurement in litres, unlike other items in the group, which were measured in kilograms.

relationship between starchy foods and other food groups. This divergence may be attributed to differences in food cuisine across countries, depending on their staple foods. It also suggests that cultural differences should be taken into consideration when addressing malnutrition through the food price and food choice pathways.

Given that starchy foods are major sources of calories in Tanzania, their complementarity with other food groups highlights opportunities for dietary diversification and improved nutrition. Since Tanzanian meals are predominantly starch-based, lower prices for meat, fish, vegetables and legumes can improve households' economic access to these foods, supporting more diverse and nutritious diets. From a consumer food-choice perspective, lower prices of complementary foods may increase the demand for starchy foods, and vice versa, reflecting interdependent food choices.

Furthermore, the demand for starchy foods exhibits low inelasticity to price changes in vegetables (0.31%), legumes (0.18%), fruit (0.13%), and milk (0.11%). Meat and fish prices have the least influence, indicating a weak relationship, likely because their high cost limits regular consumption. Consequently, price changes prompt minimal adjustments in the consumption of starchy food, which remains a dietary staple. This pattern is nutritionally undesirable, as it suggests low consumption of animal-source proteins as complementary foods, potentially exacerbating malnutrition.

Meat and fish, as well as oils and fats, complement the demand for legumes and nuts. A 1% decline in their prices increases the demand for legumes and nuts by 0.12% and 0.51%, respectively. In contrast, rising prices of starchy foods, fruits, milk and vegetables encourage substitutions toward legumes and nuts. That is, consumers tend to substitute legumes and nuts when starchy foods, fruits, milk and vegetables become expensive. Notably, substituting carbohydrates for plant-based proteins is a healthier food choice behaviour. Policies supporting legume and nut production could therefore improve their availability, affordability, protein intake and nutritional outcomes, particularly among low-income households in cases where animal-source protein is expensive.

The very low price elasticity of demand for legumes and nuts in response to fruit and vegetable prices (<0.1%) indicates a weak relationship, consistent with the findings of Ecker and Qaim (2008) in Malawi. This suggests that fruits and vegetables are poor substitutes for legumes and nuts. Nutritionally, this is plausible because fruits and vegetables provide micronutrients, vitamins and fibre, whereas legumes and nuts are important sources of protein. However, the absence of their complementarity may compromise dietary diversity and increase susceptibility to malnutrition. Ideally, legumes and nuts should complement fruits and vegetables to promote dietary diversity and healthier consumption patterns. Collectively, these three food groups constitute 52% of the six groups recommended in Tanzania's FBDGs, underscoring their nutritional importance and potential contribution to reducing malnutrition.

Meat and fish exhibit complementary relationships with legumes and nuts, fruits, vegetables, oils and fats, and milk, with relatively stronger complementarity observed for milk, fats and oils. A 1% decrease in the prices of milk, fats and oils increases demand for meat and fish by 0.42% and 0.28%, respectively. Since meat and milk are both animal-source foods, their prices may change in parallel. In contrast, a weak substitution relationship (0.013%) exists between meat and fish and starchy foods, indicating limited responsiveness to increases in staple-food prices. This may reflect the relatively high cost of meat and fish, which remains less affordable even when the prices of other food groups rise, reducing consumers' likelihood of substituting toward them. Similarly, García-Germán *et al*. (2016) reported weak substitutability between livestock products and maize and other starches in rural Tanzania, supporting these findings.

Vegetables exhibit complementary relationships with all other food groups, while fruits show similar relationships except with starchy foods. Fruit demand is more sensitive to oils and fats, and vegetable prices, as a 1% increase in their prices reduces fruit demand by 0.44% and 0.11%, respectively. Similarly, vegetable demand responds more strongly to milk, oils and fats, and fruit prices, with a 1% increase reducing demand by 0.26%, 0.26% and 0.20%, respectively. The unexpected complementarity between oils and fats and fruits may reflect their respective complementary relationships with vegetables. Their joint consumption may arise because oils and fats are commonly used to prepare vegetable-based main dishes, while fruits are often served as side dishes. Although the study did not distinguish among oil and fat types, vegetable oils, such as sunflower and palm oils, are recommended for healthier diets. Therefore, complementarity between vegetables and oils and fats should be encouraged when healthy vegetable oils are used, as this may improve dietary quality. The findings further indicate that the households' choices of fruits and vegetables are less sensitive to changes in the prices of other food groups. This can be explained by the observed low levels of fruit and vegetable prices (Table 2), which account for a small share of the household food budget. Thus, even if their prices change, households make little adjustment to their food budget allocation. Moreover, most Tanzanian meals are normally accompanied by small portions of fruits and vegetables, which attests that their consumption goes together with other food groups. This finding is congruent with the findings of Weliwita *et al*. (2003). Studies such as that of Lokuge *et al*. (2019), despite reporting a complementary relationship of fruits and vegetables with many of the food groups, also reported substitutability with starchy foods and dairy products.

Notably, fruits and vegetables exhibit a complementary relationship. A 1% decrease in vegetable prices increases fruit demand by 0.11%. This relationship may reflect the common practice of selling fruits and vegetables together in Tanzanian markets, increasing the likelihood that consumers purchase both when purchasing food. Maintaining this practice could promote greater consumption of fruits and vegetables, enhancing dietary diversity and micronutrient adequacy, which are essential for reducing the risk of malnutrition. Similar complementarity was reported by Lokuga *et al*. (2019). Other studies, including those of García-Germán (2016) and Clements and Si (2016), combined fruits and vegetables into a single food group, further underscoring their nutritional and consumption complementarity.

The findings show that milk demand increases when the prices of legumes and nuts, meat and fish, vegetables, oils and fats decline, indicating complementary relationships. However, these relationships are relatively weak, as evidenced by the small magnitude of estimated coefficients in Table 3. This suggests a limited responsiveness of milk demand to price changes in other food groups. The highest cross-price elasticity of milk demand (0.11) is observed with meat and fish, potentially because milk, meat and fish are all animal-source foods and may share similar consumption patterns. Given the important role of milk in improving dietary quality and addressing malnutrition, non-price interventions, including nutrition education and health literacy programmes, could promote milk consumption by increasing awareness of its nutritional benefits.

5. Conclusion, recommendations and study limitations

This study applied the censored quaids to estimate tej Marshallian own- and cross-price elasticities of demand for six food groups constituting a healthy diet in selected areas of Tanzania. The results show that meat and fish are the most expensive, followed by legumes, cereals and fruits, while vegetables are the cheapest. The high cost of meat and fish may restrict low-income households' access to animal-source protein, increasing the risk of malnutrition. Promoting affordable protein-rich alternatives, such as legumes and nuts, can improve access to protein. Since fruits and vegetables are relatively affordable, nutrition education could increase their consumption by raising awareness of their health benefits.

Uncompensated own-price elasticities show that demand for all food groups is sensitive to price changes, suggesting that price-based policies can influence healthy food choices. These include producer subsidies, VAT reductions, tariffs and other incentives. For example, subsidising animal-source food value chains or reducing import tariffs could lower retail prices and increase animal-protein consumption, keeping other factors such as household income constant. Similarly, subsidising sunflower producers or reducing sunflower oil import tariffs could encourage the consumption of vegetable oil.

Cross-price elasticities are relatively low, indicating that price interventions may have limited effects on substitutability or complementarity across food groups, but can effectively increase demand for targeted foods. Fruits and vegetables were complementary, meaning price changes in one affect demand for both. Therefore, policies targeting either food group could promote the consumption of both. Despite these insights, the study did not empirically compute the nutritional outcomes of dietary choices. Future research should estimate nutrient elasticities from food-group price elasticities, examine non-price factors such as household income, and simulate food-price policies to assess their effects on consumers' nutritional status.

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Appendix

Appendix 1: Coding of the variables used to construct the SES Index

Variable	Coding
Monthly median income	Continuous variable
Employment status	1 = Employed; 0 = Unemployed
Education attainment	1 = Secondary education and above; 0 = Below secondary education
Type of toilet used	1 = Flush toilet; 0 = Other types
Food poverty	1 = Above food poverty line; 0 = Living below poverty line **Note**: Computations used the 2018 food poverty line in Tanzania, which was TZS 33 748 (13 USD) per month (National Bureau of Statistics (NBS) 2019)
Primary source of water	1 = Tap water, borehole; 0 = Others
House/home ownership	1 = Owns; 0 = Doest not own
Refrigerator ownership	1 = Owns; 0 = Doest not own
Weekly household food expenditure	Continuous variable
Total monthly expenditure	Continuous variable
Number of illiterate adults in the household	Continuous variable
Number of illiterate children in the household	Continuous variable