RAAE

Review of Agricultural and Applied Economics
Acta Oeconomica et Informatica
***ISSN 1336-9261, Vol. XXV, Issue 1, 2022*: 94-103**
doi: 10.15414/raae.2022.25.01.94-103

REGULAR ARTICLE
Received: 29.9.2021; Revised: 29.1.2021; Accepted:17.3.2022; Published online: 22.3.2022

HOUSEHOLD DEMAND SYSTEM OF AFRICAN INDIGENOUS VEGETABLES IN KENYA

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ABSTRACT

Research background: Vegetables are important sources of nutrition to many households. Understanding the household demand system of leafy African indigenous vegetables (AIVs) in Kenya could enhance designing strategies to increase their consumption levels.
Purpose of the article: The study was conducted to evaluate the effects of demographic variables on budget shares for commonly consumed leafy vegetables and to generate vegetable demand elasticities.
Methods: A stratified multi-stage sampling approach selected 168 and 282 respondents in rural and urban areas, respectively. The study used primary data, and a Linear Approximate Almost Ideal Demand System was estimated using the Seemingly Unrelated Regression method.
Findings, value & novelty: Own-price elasticities indicated that leafy AIV crops are normal goods. Cross-price elasticities indicated leafy AIVs are more complementary to each other and can be substituted for the consumption of exotic vegetables. The price effect could substantially contribute to changes in demand than would income. Vegetable demand could still increase with a future increase in household income. Expenditure elasticities classified cowpea (*Vigna unguiculata* L. Walp.) and spider plant (*Cleome gynandra* L.) as necessary vegetables. Results can be used to develop strategies for increasing demand for leafy AIV crops, thus enhancing consumption of healthy diets.

Keywords*:* consumer demand; Kenya; LA/AIDS; vegetable consumption
JEL Codes: C31; D11; D12; D13

INTRODUCTION

African indigenous vegetables (AIVs) are crops whose natural habitat originated in Africa and integrated into cultures through natural, or selective, processes (**Schippers, 2002; Maundu *et al.*, 2009**). They contain adequate micronutrients and health-protecting properties (**Smith and Eyzaguirre, 2007; Singh *et al.*, 2013**) and are essential sources of food security, income, and employment (**Shackleton, 2003; Jansen van Rensburg *et al.*, 2007**).

Leafy AIV crops are hardy species and can be helpful for production in less than optimal production areas. The growth cycles of different vegetables make some of them available at other times of the year (**Mumbi *et al.*, 2006; Onim and Mwaniki, 2008**). They have the potential to correct micronutrient deficiency in developing countries. Their retail prices are affordable to low-income households who regularly depend on leafy AIVs to fulfil daily micronutrient requirements (**Weinberger and Msuya, 2004; Asian Vegetable Research and Development Center (AVRDC), 2006; Kwenin *et al.*, 2011**). Their diversity, supply, and consumption level are high during rainy seasons. During dry spells, reduction in AIV consumption is higher in poor-rural households due to low disposable income (**Weinberger and Msuya, 2004; Durham and Eales, 2006; Powel *et al.*, 2009**). Low-income families in developing countries spend a large proportion of their income on food. A small fraction of food expenditure is allocated to vegetable purchases (**Kamau *et al.*, 2011; Otunaiya and Shittu, 2014**). An indication that AIV's role in consumer diet seems marginal, especially among poorest households, and vegetables are regarded as luxuries (**Van der Lans *et al.*, 2012; Ogundari and Arifalo, 2013**).

The introduction of exotic vegetables in Africa was supported by development agencies and linked to urban or modern lifestyles and high self-esteem (**Schippers, 2002**). Food habits changed against the consumption of AIV crops, which were neglected and associated with rural-poor people (**Gotor and Irungu, 2010**). Despite the abandonment, there has been renewed interest in their production, marketing, and consumption. Several interventions have enhanced AIV consumption, and their market share and demand level has been increasing (**Smith and Eyzaguirre, 2007**).

Farmers and farmer groups, in collaboration with development agencies, and government extension services, have responded to emerging market opportunities created by increasing AIV demand. However, studies in sub-Saharan Africa indicates that the market demand for leafy AIV crops is high, especially in urban areas (**Ruel *et al.*, 2005; Mwangi and Mumbi, 2006; Ngugi *et al.*, 2007; Muhanji *et al.*, 2011**). Moreover, a high market potential still exists due to increasing populations, urbanization, and possibilities of intensifying interventions in delivering leafy AIVs to nearby urban centres (**Ngugi *et al.*, 2007**). Understanding a complete demand system for leafy AIV crops is vital in designing strategies for exploiting their full potentials in developing countries. Besides price, income, diversity, and seasonality, some studies indicate demographic variables are important factors in explaining vegetable demand patterns (**Ogundari and Arifalo, 2013; Ayanwale *et al.*, 2016**).

Ruel *et al.* (2005) used an Almost Ideal Demand System (AIDS) model but did not wholly disaggregate vegetables into discrete crops. Although **Bundi (2012)** completely disaggregated vegetables using the AIDS model, AIVs were not part of this analysis. The only study that came close to the present research is **by Amaza (2009)**, which analysed the demand for traditional African vegetables and sweet potatoes in Kenya and Tanzania. However, the weak separability assumption was violated, and selectivity biasness resulting from zero consumption responses was not corrected in the analysis. Effects of demographic variables on vegetable demand have been previously not evaluated. Demographics capture differences in consumer characteristics, influencing household economic response to food consumption (**Pollak and Wales, 1981; Dudek, 2010**).

The objective of this study was to evaluate the household demand system of leafy AIVs. This involves examining vegetable demand behavior of households at finer level of disaggregation by estimating price and income elasticities of commonly consumed vegetables in Kenya. For comparison purposes, exotic leafy vegetables were included in the analysis. The uniqueness of this study is the integration of demographic variables, correcting for selectivity bias, and completely disaggregating vegetables into independent crops using a complete demand systems approach.

Theoretical framework

The theoretical framework is a household based model. However, the study assumes that households are net consumers and have no preference for the products they intend to produce for consumption. Thus, the Marshallian demand function is best fit because most households are market based environment and not producer based market informed. From Random utility theory, primal and duality approaches can be used to estimate demand functions. According to **Varian (1992)**, primal preference approach is derived from utility maximization theory, where utility is expressed as a function of price and income. The approach assumes rational consumers selects a preferable bundle of goods from a set of affordable alternatives, given a budget constraint. In this regard, direct utility is expressed as a function of quantities of goods consumed subject to a budget line as shown in Equation (1).

$$Max\ U = U(Q) \quad s.t \quad M = \sum_{k=1}^{n} p_k\, q_k \tag{1}$$

where; Q is a vector of n goods demanded, M is fixed consumer income (total expenditure), and $P = (p_1, p_2, \dots\dots p_k)$ is a vector of prices for goods $1,2,\dots.k$ demanded. From utility maximization framework, derived demand for each good is obtained using Lagrangian method (Equation 2).

$$\mathrm{L}(\mathrm{Q},\lambda) = U(Q) + \lambda(M - \sum_{k=1}^{n} p_k\, q_k) \tag{2}$$

Where: λ is Lagrangian multiplier (marginal utility of income). Deriving first order condition with respect to q_i and λ, and subsequently solving the resulting equations simultaneously with respect to q_i, Marshallian or uncompensated demand function is obtained using Equation (3).

$$\left.\begin{matrix} q_i = \emptyset_i(P,M) \\ Q^* = \emptyset_i(P,M) \end{matrix}\right\} \tag{3}$$

Where: q_i and Q^* is Marshallian demand function for good i and for the entire set of goods demanded, respectively. Substituting Equation (3) into Equation (1), an indirect utility function is obtained by Equation (4).

$$U^* = V(P,M) \tag{4}$$

Where: $V(P,M)$ is the maximum utility attainable at given prices and income level.

On the other hand, duality theory assumes utility maximization is derived from expenditure or cost minimization. In this approach, expenditure is expressed as a function of utility and price. The objective function under duality is given as Equation (5).

$$MinU = M = \sum_{k=1}^{n} p_k\, q_k \qquad s.t \qquad U = U(Q) \tag{5}$$

Adopting Lagrangian procedure, optimal values of Q are obtained, which are denoted as Equation (6).

$$U^* = h(U,P) \tag{6}$$

Equation (6) is Hicksian or income compensated demand function (**Varian, 1992**) implying that holding utility fixed, Q is influenced by a vector of prices for goods demanded.

DATA AND METHODS

Study area and sampling design

The study used a stratified multi-stage sampling approach to select respondents who were interviewed at retail outlets after purchasing leafy vegetables. In the first stage, Nairobi, Nakuru, Kisii, and Kakamega counties in Kenya were purposively sampled. Kisii and Kakamega are among rural counties with large AIV production levels, while Nakuru and Nairobi are among urban counties with final markets, where AIVs from different production zones are sold. The second and third stages were stratified based on information obtained from sub-county agricultural offices. In the second stage, one sub-county from each county, identified as significant areas where large volumes of AIVs are produced or consumed, was chosen. The third stage involved stratification of market outlets. In urban areas, markets were stratified into supermarkets, green groceries, and local open-air retail outlets. In rural areas, farm gates, green groceries, and local open-air retail outlets were classified. In the fourth stage, simple random sampling was used to select an equal number of respondents from each retail outlet. Ultimately, 450 respondents were selected, distributed proportionately to population size at the county level, resulting in 168 and 282 respondents in rural and urban areas, respectively. Responses to the semi-structured questionnaire through face-to-face interviews were obtained in July 2015. The questionnaire was designed to elicit information on the price and quantities of commonly consumed leafy vegetables in the study area and on demographic variables including; location, age, gender, education, household size and composition, and income.

Multistage budgeting, weak separability assumption, and model selection

A three-step multistage budgeting technique was utilized. The first stage involves allocating disposable income over broad categories of food and non-food expenditures. In the second stage, food expenditure is allocated to vegetables and other food commodities. The third stage involves allocating vegetable expenditure across disaggregated vegetable crops commonly consumed in the study area. These were: cowpea (*Vigna unguiculata* L. Walp.) (CP), amaranth (*Amaranthus cruentus* L.) (AM), spider plant (*Cleome gynandra* L.) (SP), African nightshade (*Solanum scabrum* Mill.) (NS), jute mallow (*Corchorus olitorius* L.) (JM), slender leaf (*Crotalaria brevidens* Benth) (SL), cabbage (*Brassica oleracea* L.) (CG), kales (*Brassica oleracea var acephala*) (KL) and spinach (*Spinacia oleracea* L.) (SN). Among these vegetables, CP, AM, SP, NS, JM, and SL are leafy AIV crops, while CG, KL, and SN are exotic vegetables. A stepwise process is convenient in estimating a demand system because only total expenditure on commodities within a sub-category is required (**Phlips, 1974**). The study assumed weak separability of the utility function where the marginal rate of substitution of any two vegetables is independent of quantities of other food commodities consumed outside the vegetable sub-category (**Edgerton, 1997**).

Interdependence in consumer choices necessitates the use of a system approach over a single equation method in estimating commodity demand, since the former permits commodity substitution (**Dudek, 2010; Bett *et al.*, 2012**). Commonly used system approaches include Linear Expenditure Systems (**Stone, 1954**); AIDS (**Deaton and Muellbauer, 1980a**); Generalized Almost Ideal Demand Systems (**Billino, 1990**); and Quadratic Almost Ideal Demand System (**Banks *et al.*, 1997**). Model selection for demand analysis depends on the ease of estimation and ability to generate estimates consistent with demand theory (**Wang *et al.*, 1996**). The current study used the Linear Approximate Almost Ideal Demand System (LA/AIDS) model since its parameters are relatively easy to estimate. It also allows testing for principle restrictions of the demand system. Additionally, axioms of choice are exactly satisfied, and the model is flexible in explaining how income and price variations influence demand responses using data from household expenditure (**Deaton and Muellbauer, 1980a; Lee *et al.*, 1994**).

Empirical derivation of the LA/**AIDS *model***

Generating biased parameter estimates was avoided by using the Heckman two-step technique to censor observed zero values of dependent variables, correcting for selectivity bias (**Heckman, 1979; Heien & Wessells, 1990**). In the first stage, a selection equation (Probit model) estimated the probability of consuming each of the selected vegetables (Equation 7).

$$Y_{ih} = f(P_{ih}, P_{(j-1)h}, M_h, X_h) \tag{7}$$

Where: Y_{ih} represents vegetable consumption i by household h ($Y_{ih} = 1$ if vegetable i was consumed, otherwise 0), P_{ih} is the price of vegetable i, $P_{(j-1)h}$ indicates prices for other vegetables, M_h is expenditure (total income allocated) on vegetable consumption, and X_h is a vector of demographic variables explaining household h.

The Probit regression also estimated the Inverse Mills Ratio (IMR) λ_{ith} for a household h in consuming vegetable i (Equation 8).

$$\lambda_{ith} = \frac{\emptyset(P_h,\ M_h,\ X_h)}{\varphi(P_h,\ M_h,\ X_h)} \tag{8}$$

Where P_h is a vector of prices; X_h as explained above; $\emptyset$ is standard normal density function; φ is the standard normal cumulative distribution function. Similarly, IMR for zero consumption of each of the selected vegetables by household h was derived as in Equation (9).

$$\lambda_{ith} = \frac{\emptyset(P_h,\ M_h,\ X_h)}{1-\varphi(P_h,\ M_h,\ X_h)} \tag{9}$$

The IMR for each variety was included as an instrument in the second-stage of the regression to censor latent variables, where a complete demand system (LA/AIDS) was estimated using the Seemingly Unrelated Regression method (**Zellner, 1963**) (Equation 10).

$$\mathrm{W}_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ \mathrm{In}\, P_j + \beta_i \,\mathrm{In}\left(\frac{m}{P}\right) + \sum_{j=1}^{n} \gamma_{kj} x_k + \beta_{w_i}\lambda_i + \mu_i \tag{10}$$

Where: W_i is the budget share of vegetable i-derived as $\mathrm{W}_i = {(p_i q_i)}/{m}$ in which q_i is the quantity of vegetable i purchased; α_i is a constant coefficient in i^{th} share equation; γ_{ij} is slope coefficient associated with j^{th} good in i^{th} share equation; P_j is the price of the j^{th} commodity; n is number of vegetable crops; x_k are demographic variables which are z in total; λ_i is inverse mills ratio; μ_i is a random variable with zero mean and constant variance; m is the total expenditure on selected vegetables analysed, given as $m = \sum_{j=1}^{n} p_i\, q_1$; and P is the price index for aggregate food provided by Equation (11).

$$\ln(P) = \alpha_0 + \sum_j^n \alpha_i \ \ln(P_j) + \frac{1}{2}\sum_j^n \sum_i^n \ln(P_i)\ln(P_j) \quad (11)$$

It is empirically difficult to derive a price index using Equation (11); hence it was approximated using the Stone Price Index (**Green & Alston, 1990**) as shown in Equation (12).

$$\ln(P) = \sum_i^n \overline{w} \ \ln P_i \quad (12)$$

Where: $\overline{w}$ is mean budget share. This process minimizes the effects of multicollinearity, retains linearity in estimation, and enhances the inclusion of demographic variables by either translation or scaling method (**Pollak & Wales, 1981; Sadoulet & de Janvry, 1995**).

Theoretically, the demand system has to satisfy three-parameter requirements. Firstly, the adding up restriction requires equality between the estimated household budget and total expenditure on goods. Secondly, homogeneity restriction implies a proportionate change in expenditure, and prices leave quantity demanded unchanged. Thirdly, symmetry restriction indicates the substitution matrix is symmetric. Thus, cross-price derivatives are negative and semi-definite, implying Hicksian demand function slopes downwards (**Deaton & Muellbauer, 1980b; Varian, 1992; Edgerton, 1997**). These restrictions are satisfied as Equation (13) – Equation (15).

Adding up

$$\begin{Bmatrix} \sum_i^n \alpha_i = 0; & \sum_i^n \gamma_{ij} = 0; & \sum_i^n \beta_o = 0 \\ \sum_i^n w_i = 0; & j = 1, \ldots\ldots\ldots\ldots\ldots, n \end{Bmatrix} \quad (13)$$

Homogeneity

$$\left\{\sum_i^n \gamma_{jk} = 0; j = 1, \ldots\ldots\ldots.. n\right\} \quad (14)$$

Symmetry

$$\{\gamma_{ij} = \gamma_{ji}\} \quad (15)$$

Parameters estimated from LA/AIDS equation form the basis for generating Marshallian and Hicksian elasticities. According to **Green & Alston (1990)** and **Hayes *et al.* (1990)**, Marshallian price and expenditure elasticity estimates are first obtained.

Marshallian expenditure elasticity (Equation 16).

$$e_i = 1 + \left(\frac{1}{w_i}\right)\left(\frac{\partial w_i}{\partial \log x}\right) = 1 + \frac{\beta_i}{w_i} \quad (16)$$

Marshallian own-price elasticity (Equation 17).

$$S_{ii}^M = -1 + \left(\frac{\gamma_{ii}}{w_i}\right) - \beta_i \quad (17)$$

Marshallian cross-price elasticity (Equation 18).

$$S_{ij}^M = -\delta_{ij} + \left(\frac{\gamma_{ii}}{w_i}\right) - \left(\frac{\beta_{ij}}{w_i}\right), \forall_i, j = 1, \ldots n \quad (18)$$

Where: δ_{ij} is Kronecker delta in which $\delta_{ij} = 1$ for $1 = j$ (for own-price elasticity), while $\delta_{ij} = 0$ for $1 \neq j$ (for cross-price elasticity). Hicksian elasticities for good i with respect to j are then derived from Marshallian price elasticities using Slutsky equation as Equation (19) – Equation (20).

Hicksian own-price elasticity

$$S_{ii}^M = -1 + \left(\frac{\gamma_{ii}}{\overline{w_i}}\right) - \overline{w_i} \quad (19)$$

Hicksian cross-price elasticity

$$S_{ij}^M = -\delta_{ij} + \left(\frac{\gamma_{ii}}{\overline{w_i}}\right) + \overline{w_i}, \forall_i, j = 1, \ldots n \quad (20)$$

Marginal expenditure shares, which show how future household expenditure on vegetables would be affected by changes in income, were obtained by multiplying expenditure elasticities with expenditure shares allocated to each vegetable crop (**Agbola, 2003; Bett *et al.*, 2012**). Income elasticities are obtained by multiplying expenditure elasticities and coefficient of natural log of T, where T is the total expenditure on food and non-food items. The coefficient of $\ln T$ is derived from Equation (21).

$$\ln R = \alpha_0 + \alpha_1 \ln T + \beta \ln P + \sum_{k=1}^z \gamma_k x_k + \mu \quad (21)$$

Where: R is the total expenditure on vegetable products.

The singularity error in the variance-covariance matrix was avoided by dropping the spinach equation and later recovered by imposing the demand system's adding-up restriction. A similar forum for the LA/AIDS model has been used in other studies to estimate food demand patterns (e.g., **Jabarin & Al-Karableh, 2011; Naanwaab & Yeboah, 2012; Bett *et al.*, 2012; Basarir, 2013**). Demographic variables included in the empirical model (Table 1) are drawn from previous related studies (**Bett *et al.*, 2012; Basarir, 2013; Ogundari & Arifalo, 2013; Ayanwale *et al.*, 2016**).

RESULTS AND DISCUSSION

Descriptive results

Descriptive results on demographic variables are presented in Table 1. The mean age for key decision-makers was about 42 years, with approximately ten years of schooling. The average household size was approximately five family members, with about 27% below 14 years of age. On average, households had 24 years of AIV consumption experience. Moreover, about 64% of respondents were urban dwellers, and nearly 32% of key decision-makers were male.

Weekly consumption, expenditure allocation, and budget share were highest on NS, followed by SP (Table 2). Expenditures on JM, SL, and CG were the least. Expenditure on KL and SN were fairly allocated. About 18.09% of the vegetable budget was allocated on NS, while approximately 5.43% was apportioned on SL share.

Effect of demographics, price and expenditure coefficients on vegetable budget shares

Table 3 shows evaluated maximum likelihood estimates for demographic effects on vegetable budget shares. A significant inverse mills ratio on CP indicates the estimated parameter would be biased and inconsistent if non-consumers of CP were excluded in the analysis. Urban dwellers were less likely to allocate KL and CG budget shares. These results were against study expectations as urban dwellers prefer vegetables that require less preparation time and are more convenient to cook, like KL and CG. Perhaps the ongoing promotional campaigns in urban areas about the importance of leafy

AIVs have enhanced nutritional awareness, thus declining KL and CG preference (**Ngugi *et al.*, 2007**).

Male decision-makers were less likely to allocate AM and JM shares. However, they positively influenced KL share. Perhaps male decision-makers prefer KL since its recipe does not necessarily require blending with other vegetables. Contrary, AM, and JM require mixing with other vegetables to improve their taste and palatability. The implication is that extra time and adequate indigenous knowledge to attach perfect complements is likely a constraint among male decision-makers. More years of education positively influenced the odds of allocating CP, SP, and JM shares and negatively affected CG share. These findings demonstrate that more educated households prefer AIVs to exotic vegetables. Perhaps their higher advancement in knowledge informs their decision to select more nutritious diets.

Large households were more likely to allocate CP and CG shares. CP has about seven seasons per annum (**Mumbi *et al.*, 2006**), an agronomic advantage that enhances its availability, making it more reliable, especially for large households. The market price for CG is relatively lower than other vegetables, improving its affordability in larger families, who require larger quantities of vegetables per meal. Moreover, SL was less preferred in households with most members aged at least 14 years old. Probably, the bitter taste associated with SL makes it an undesirable vegetable, especially when not cooked well (**Abukutsa, 2007**). Contrary, households with more years of AIV consumption were more likely to allocate NS and SL shares. Perhaps more experienced AIV consumers value the bitter taste associated with NS and SL vegetables as an essential medicinal property for healing stomach-related diseases (**Maundu *et al.*, 1999; Schippers, 2002**).

Results in Table 4 shows that the effects of price and expenditure coefficients on vegetable budget shares varied. Apart from JM, own-price coefficients for other vegetable shares were positive. Own-price coefficients were significant for all vegetables except JM and SL, implying that price changes would significantly affect the quantity demanded of CP, AM, SP, NS, KL, and CG. Expenditure coefficients were positively significant for AM, NS, and SL shares, indicating that their purchased quantities would increase upon an increase in real income. Contrary, shares for CP and CG would significantly reduce as a result of the change.

Effect of own-price and cross-price elasticities on vegetable shares

Table 5 presents own and cross-price elasticities results, comprising Marshallian (uncompensated) and Hicksian (compensated) price elasticities. All vegetables considered in this study are normal goods. This explains the concavity of the expenditure function, hence satisfying the negativity of substitution effect on the Hicksian demand curve.

Apart from JM, other uncompensated own-price elasticities of vegetable demand were < 1 in absolute terms thus, inelastic. The implication is that a fall in own prices would lead to a less proportionate increase in quantity demanded of CP, AM, SP, NS, SL, KL, CG, and SN shares.

Table 1: Definition of variables and descriptive statistics

Variable	Variable definition and measurement	Mean	S.E[a]
Age	Age of the decision-maker[b] (years).	41.56	0.698
Educ	Education level of the decision-maker (years).	10.04	0.267
Hsize	Number of members in a household.	4.80	0.123
Hs1	Proportion of household members < 14 years.	0.27	0.013
Hs2	Proportion of the household members ≥14 years.	0.73	0.013
Gender	Proportion of male decision-maker.	0.32	0.027
Exper	Years of AIV consumption in a household.	24.25	0.987
Loc	1 if the household is located in urban areas, 0 otherwise.	0.64	0.028
Lnpid	Real vegetable expenditure.	0.92	0.011
Imr	Inverse mills ratios.		
$P_1, P_2, \ldots, P_9$	Prices for CP, AM, SP, NS, JM, SL, SW, CG and SN vegetables, respectively.		

Note: [a] S.E. = standard error; [b] Decision maker is a household member responsible for key decisions on matters concerning food consumption.

Table 2: Weekly consumption, vegetable expenditure, and budget shares

Type of vegetable	Percent of Consumers	Mean Expenditure (KES[a])	Budget share
Cowpea (CP)	75.40	215.86	0.1648
Amaranthus (AM)	71.90	181.96	0.1265
Spider plant (SP)	76.30	219.51	0.1600
African nightshade (NS)	81.70	256.26	0.1809
Jute mallow (JM)	42.90	82.25	0.0593
Slender leaf (SL)	37.50	83.79	0.0543
Kales (KL)	66.90	130.41	0.1086
Cabbage (CG)	46.70	89.79	0.0717
Spinach (SN)	56.20	106.31	0.0739

Note: [a]1US$ = 102.04 Kenyan Shillings (KES).

Table 3: Effects of demographic variables on vegetable budget shares

Variable	Share of vegetable crops								
	CP	AM	SP	NS	JM	SL	KL	CG	SN
Loc	0.021	-0.002	0.027	-0.006	0.016	0.010	-0.033**	-0.040***	0.007
	(0,019)	(0.013)	(0.019)	(0.017)	(0.011)	(0.011)	(0.016)	(0.013)	
Age	-0.001	0.003	-0.001	0.012	0.001	-0.001	-0.009	0.003	-0.006
	(0.009)	(0.006)	(0.009)	(0.008)	(0.005)	(0.005)	(0.008)	(0.006)	
Gender	0.026	-0.029**	0.008	0.020	-0.019*	-0.010	0.034**	-0.016	-0.014
	(0.019)	(0.013)	(0.019)	(0.017)	(0.011)	(0.011)	(0.016)	(0.013)	
Educ	0.004*	-0.001	0.001***	0.002	0.014**	0.001	-0.005	-0.026*	-0.002
	(0.002)	(0.002)	(0.002)	(0.019)	(0.012)	(0.001)	(0.018)	(0.014)	
Hsize	0.010**	-0.003	0.003	-0.004	-0.004	-0.007	0.004	0.005*	0.002
	(0.005)	(0.003)	(0.002)	(0.004)	(0.006)	(0.004)	(0.008)	(0.003)	
Hs1	0.301	0.081	0.259	-0.151	0.013	-0.040	-0.200	-0.281	0.016
	(0.403)	(0.272)	(0.398)	(0.343)	(0.224)	(0.220)	(0.328)	(0.263)	
Hs2	0.282	0.069	0.238	-0.176	0.031	-0.058*	-0.169	-0.254	0.038
	(0.402)	(0.271)	(0.397)	(0.343)	(0.223)	(0.019)	(0.328)	(0.263)	
Exper	0.001	-0.005	0.003	0.002***	0.005	0.008*	0.003	-0.001	-0.001
	(0.008)	(0.006)	(0.008)	(0.007)	(0.001)	(0.005)	(0.007)	(0.005)	
Imr	-0.041*	0.004	-0.013	0.003	0.016	0.003	0.009	0.020	0.003
	(0.024)	(0.016)	(0.023)	(0.020)	(0.013)	(0.013)	(0.019)	(0.015)	

Note: ***, **, *denotes 1, 5, or 10% level of significance, respectively; values in parentheses indicate standard error.

Table 4: Own and cross-price elasticities for vegetable demand

Shares	CP	AM	SP	NS	JM	SL	KL	CG	SN
Marshallian (uncompensated) price elasticities									
CP	**-0.864**	0.087	0.240	0.909	-0.678	-1.897	0.174	2.677	0.149
AM	1.076	**-0.211**	-0.946	-0.865	-0.791	-1.815	0.096	2.883	0.141
SP	1.065	-1.061	**-0.677**	0.856	0.969	-2.023	0.520	2.526	0.322
NS	1.265	-0.728	0.244	**-0.920**	-1.277	-1.895	0.092	2.898	0.049
JM	-1.361	-1.216	0.162	-1.115	**-1.506**	-1.562	0.108	2.967	0.077
SL	-0.769	-1.218	-0.143	-1.503	-1.047	**-0.833**	0.243	2.366	0.453
KL	1.125	1.752	0.136	1.776	1.269	2.239	**-0.845**	2.742	-1.086
CG	2.066	0.046	1.198	0.013	0.195	0.849	0.723	**-0.585**	1.062
SN	1.210	0.882	0.393	0.949	0.812	1.800	-0.202	2.805	**-0.744**
Hicksian (compensated) price elasticities									
CP	**-0.500**	0.163	0.036	0.208	-0.087	-0.100	0.020	0.275	0.057
AM	0.161	**-0.196**	-0.006	-0.221	-0.194	-0.042	0.136	0.056	0.092
SP	0.030	-0.032	**-0.454**	0.265	0.080	-0.039	0.215	0.150	0.100
NS	0.020	-0.052	0.005	**-0.911**	-0.098	-0.169	0.210	0.207	0.079
JM	-0.230	-0.281	0.011	-0.197	**-1.495**	-0.041	0.219	0.165	0.192
SL	-0.316	-0.207	-0.071	-0.015	-0.008	**-0.877**	0.418	0.234	0.164
KL	0.276	0.209	0.091	0.373	0.175	0.104	**-0.759**	0.367	-0.212
CG	0.079	0.743	0.369	0.646	0.398	0.384	0.644	**-0.323**	0.845
SN	1.021	0.963	0.965	1.117	1.066	1.006	-1.034	0.612	**-0.682**

Note: The bold values are the own-price elasticities.

Table 5: Marginal shares, income and expenditure elasticities for vegetable demand

CP	AM	SP	NS	JM	SL	KL	CG	SN
Marginal expenditure shares								
0.035	0.238	0.097	0.353	0.108	0.152	0.131	-0.129	0.086
Expenditure elasticities								
0.210	1.882	0.607	1.949	1.812	2.800	1.202	-1.805	1.167
Income elasticities								
0.144	1.291	0.416	1.337	1.243	1.921	0.824	-1.238	0.800

Table 6: Effect of price and expenditure coefficients on vegetable budget shares

Prices	Shares of vegetable varieties								
	CP	AM	SP	NS	JM	SL	SW	CG	SN
P1	0.045*	-0.048***	-0.033*	0.004	0.004	0.007	-0.015	0.033***	-0.003
	(0.026)	(0.014)	(0.019)	(0.017)	(0.013)	(0.013)	(0.015)	(0.012)	
P2	-0.048***	0.116***	-0.026*	-0.002	0.010	-0.019	-0.003	-0.023**	-0.005
	(0.015)	(0.018)	(0.014)	(0.014)	(0.012)	(0.012)	(0.012)	(0.009)	
P3	-0.033*	-0.026*	0.077***	0.002	-0.008	-0.014	0.006	0.001	-0.007
	(0.019)	(0.014)	(0.024)	(0.016)	(0.013)	(0.013)	(0.015)	(0.011)	
P4	0.004	-0.002	0.002	0.047**	0.002	-0.010	-0.027**	-0.020*	0.003
	(0.017)	(0.014)	(0.016)	(0.021)	(0.012)	(0.012)	(0.013)	(0.010)	
P5	0.004	0.010	-0.008	0.002	-0.027	-0.005	0.008	0.007	0.008
	(0.013)	(0.012)	(0.013)	(0.012)	(0.019)	(0.015)	(0.012)	(0.008)	
P6	0.007	-0.019	-0.014	-0.010	-0.005	0.012	0.016	0.008	0.004
	(0.013)	(0.012)	(0.013)	(0.012)	(0.015)	(0.018)	(0.011)	(0.008)	
P7	-0.015	-0.003	0.006	-0.027**	0.008	0.016	0.029*	-0.015	0.002
	(0.015)	(0.012)	(0.015)	(0.013)	(0.012)	(0.011)	(0.017)	(0.009)	
P8	0.033***	-0.023**	0.001	-0.020**	0.007	0.008	-0.015	0.035***	-0.027
	(0.012)	(0.009)	(0.011)	(0.010)	(0.008)	(0.008)	(0.009)	(0.001)	
P9	-0.003	-0.005	-0.007	0.003	0.008	0.004	0.002	-0.027***	0.024
	(0.013)	(0.012)	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)	(0.008)	
Constant	-0.002	-0.054	-0.069	0.169	0.018	-0.017	0.304	0.549**	-0.898
	(0.399)	(0.269)	(0.394)	(0.341)	(0.222)	(0.218)	(0.326)	(0.261)	
Lnpid (β_{ij})	-0.199***	0.112***	-0.063	0.172***	0.048	0.098***	0.022	-0.201***	0.012
	(0.056)	(0.039)	(0.055)	(0.048)	(0.033)	(0.032)	(0.045)	(0.039)	

Note: ***, ** and *represents significance at 1%, 5% and 10% level, respectively.
Values in parenthesis indicates the standard errors.

More income would be allocated to AM share if all vegetable prices increased uniformly. However, a uniform decrease in vegetable price would significantly favour JM share. Similar findings on JM were obtained by **Jabarin and Al-Karablieh (2011)**.

All compensated own-price elasticities were also negative, confirming the downward sloping of the Hicksian demand curve with asymmetric, non-positive semi-definite substitution matrix (**Varian, 1992**). Like Marshallian own-price elasticities, Hicksian own-price elasticities of vegetable demand were < 1 in absolute terms, except for JM. An indication that apart from JM, quantities demanded of other shares would not change significantly even if their respective prices changed.

Marshallian and Hicksian price elasticities had similar signs implying that both income and substitution effects would contribute proportionate weights in influencing vegetable purchases for any price change. Compared to uncompensated own-price elasticities, the magnitude of compensated own-price elasticities was higher, indicating that price effect would contribute a more significant proportion of increased demand than income effect in the case of a price decline. Uncompensated own-price elasticity for CP, as an example, implies a 10% drop in CP price would stimulate its demand by 8.6%, where the price effect contributes about 5.0% (compensated own-price elasticity). In comparison, approximately 3.6% would be accounted for by income effect.

Negative Marshallian and Hicksian cross-price elasticities imply the respective vegetable pairs are complimentary, otherwise substitutes. Out of 30 cross-price elasticities among leafy AIV crops, 20 were negative while 10 were positive, indicating leafy AIVs complement each other in consumption than they substitute. For instance, holding price for AM and JM constant, if the price for CP increases by 10%, quantity demanded of AM increases by 0.87%, with pure price accounting for 16.3% of the increased demand. Similarly, the amount demanded of JM would decline by 6.78% as a result of the change. Generally, leafy AIV crops were substitutes for exotic vegetables. Among exotic vegetables, CG substitutes KL and SN, which were also found to be complementary products.

Effect of marginal shares, income and expenditure elasticities on vegetable demand

Results on marginal expenditure shares, income, and expenditure elasticities are presented in Table 6. Marginal expenditure shares for all vegetable sum to one, satisfying the adding up the restriction of the demand system. Apart from CG, other marginal expenditure shares were positive, implying that a future increase in household income would proportionately increase their purchases. As a result, NS would receive the highest (about 35%) proportionate increase in quantity purchased while SN the least (about 9%). Contrary, consumption of CG would proportionately decline due to its negative marginal expenditure share.

Similarly, apart from CG, expenditure and income elasticities for other vegetables were positive, implying normal goods, with elastic income elasticity of demand. Of the nine vegetable crops evaluated, only CP and SP had expenditure elasticities < 1; thus, they can be considered necessary to the household diet. Likewise, AM, NS, JM, SL, KL, and SN can be classified as luxury vegetables since their expenditure elasticities were > 1.

CONCLUSIONS AND RECOMMENDATIONS

The largest proportion of the vegetable budget was allocated on NS, while SL received the slightest share. Shares of different vegetables were significantly influenced by the decision-makers' household location, gender, and education level, household size, composition, and AIV consumption experience. The similarity between compensated and uncompensated price elasticities shows that income and substitution effects proportionately influence vegetable purchases due to price changes. Own-price elasticities indicate that all analysed vegetables are normal products. Hence a uniform increase in price would decrease the quantity demanded. Cross-price elasticities suggest leafy AIV crops are more complementary to each other. However, they are absolute substitutes for exotic vegetables. From expenditure elasticity results, CP and SP can be classified as necessary vegetables due to their less responsiveness to changes in income, probably because they are bought more regularly and in reasonably constant amounts. Likewise, AM, NS, JM, SL, SW, and SN are considered luxury vegetables to the household diet.

Findings from this study have policy implications on food accessibility, which is one of the elements of food security. Even though a future increase in income would proportionately increase vegetable purchases, the magnitude of the price effect outweighs that of the income effect. The implication is that policies favouring the general increase in household income would not significantly increase vegetable demand instead of price regulations. Thus, consumers would purchase more AIVs if price policies were favourable. In this regard, two commentary interventions are proposed; subsidization of farm inputs, remarkably certified seeds to reduce production costs, followed by a price ceiling that could protect and motivate AIV purchases, especially in large households.

Moreover, eliminating brokers from the vegetable value chain could reduce the retail price in favour of consumers. Additionally, utilization of leafy AIVs for health purposes was confirmed by more experienced consumers. Therefore, demand for leafy AIV crops could increase by designing educational programs to improve consumer awareness of their medicinal and nutritional benefits, especially in male decision-makers.

Acknowledgement

The authors are grateful for research grants from Horticultural Innovations and Learning for Improved Nutrition and Livelihood in East Africa (HORTINLEA) project funded by the Federal Ministry of Education and Research and the Federal Ministry for Economic Cooperation and Development of Germany. We recognize the input received from respondents. The project was undertaken by collaborating between Humboldt University of Berlin, Germany, and Egerton University, Kenya. The views expressed herein are solely those of the authors and not of the affiliated institutions.

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