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Estimation of food demand parameters in Kenya

A Quadratic Almost Ideal Demand System (QUAIDS) approach

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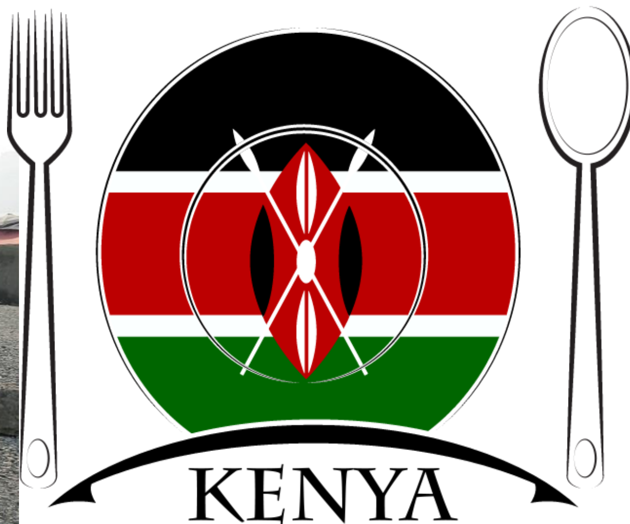

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Contents

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Alfredo Mainar Causapé (European Commission, Joint Research Centre (JRC), Seville, Spain), identified and assigned the regions and sub-groups of households into which they are divided and prepared databases based on the microdata of the Household Budget Survey (KIHBS) for use in this analysis.

Abstract

Food security is a key topic for the Kenyan economy. This report contributes to the improvement of the understanding of the demand-side drivers of food demand patterns and their evolution in respect to changes in income and prices in this country. The report provides a new estimate of expenditure and price elasticities for goods consumed by households in Kenya. The estimation approach employed is based on the Quadratic Almost Ideal Demand System (QUAIDS) which depicts the demand system in a flexible way by imposing less restrictive marginal expenditure shares. The estimations are performed for 4 different levels of commodity grouping and also at the regional level, yielding significant income and price elasticities at all levels. These estimations will contribute to improve the overall food security analysis and in particularly can be useful to enhance the demand side of economic simulation models largely employed by JRC.

1 Introduction

The Directorate Sustainable Resources of the Joint Research Centre (JRC) of the European Commission, based in Seville (Spain), provide the scientific knowledge for EU policies related to the sustainable use of resources and related socio-economic aspects. Within this capacity, the JRC is committed to providing: (i) support for the improvement of information systems on agriculture, nutrition and food security, (ii) policy and economic analysis to support policy decision-making processes and (iii) scientific advice on selected topics concerning sustainable agriculture and food and nutrition security under an Administrative Arrangement between the Directorate-General (DG) for International Cooperation and Development (DEVCO) – EuropeAid and DG JRC. Under this framework, the Economics of Agriculture Unit of the Sustainable Development Directorate is responsible for elaborating on the methodology and tools used for the analysis of national and regional economic systems, including the assessment of the sustainability of policies in the sectors of agriculture, social transfers and the fight against food and nutrition insecurity.

JRC is developing a single country CGE model that takes the specific conditions of developing countries, namely Dynamic Equilibrium Model of Economic Development, Resources and Agriculture (DEMETRA). The model is employed to provide evidence based policy support to stakeholders engaged with JRC in selected partner countries. Kenya is among these partner countries. The support given by JRC to the stakeholders in Kenya covers agricultural policy formulation and its impacts on food and nutrition security. Hence, verification of the model parameterization especially for the food demand and production systems is crucial to ensure the quality of the analysis done by using DEMETRA model. This study aims at deriving the parameters required by DEMETRA model to better represent the Kenya household food demand by using a large and detailed data source and cutting-edge econometric techniques.

The rest of the report is organised as follow: Section 2 analyses the current approaches on the demand system estimation. Section 3 provides an overview on the relationship between food demand and food security and how this has been analysed in the academic literature, while Section 4 presents the model adopted for this study. Section 5 introduces the data and the estimation strategy while in Section 6 results are presented and discussed. Section 7 concludes.

2 Literature review on demand systems

The challenge of estimating demand functions is to maintain empirical applications coherent with microeconomic theory. Specifically, the literature on demand functions estimations had to deal with assumptions and restrictions from demand and consumer behaviour theories. The idea of using systems of equations to estimate demand functions was initially introduced by Stone in 1954. Stone developed the Linear Expenditure System (LES) to estimate the linear relationship between expenditure and prices by fulfilling the regularity conditions of demand theory and testing for some of the restrictions imposed by consumer theory, namely homogeneity and symmetry. Soon after, Theil (1965) developed the Rotterdam model, also a linear model.

The LES and Rotterdam's successful diffusion was linked to the simplicity of their estimation, which is due to linearity and the small number of parameters required. Both models perform well when the elasticity of substitution among goods is low. However, often the elasticity of substitution is low at higher levels of aggregation; therefore the performance of the two models can be less robust with highly disaggregated bundles of goods.

Despite the LES and the Rotterdam models represented an important step forward in the estimation of demand functions, they soon showed some drawbacks. There are some limiting constraints that they cannot overcome: i) the goods are Hicksian substitutes, meaning that they ignore the substitution among goods in the case of changing relative prices; ii) there is direct (linear) proportionality between price and expenditure changes; iii) expenditure elasticities are always positive, meaning that they do not capture inferior goods; iii) they assume constant marginal budget shares, meaning that the non-linearity of the Engel's curves is not considered and that flexibility is quite limited.

Since the LES and the Rotterdam models, a number of demand systems have been developed aiming to solve some of the constraints mentioned. The demand systems that followed the LES and Rotterdam models can be distinguished in two main groups.

The first group consists of demand systems aiming to achieve more flexible functional forms. That is, functional forms that respect consumer behaviour theory but that do not assume *a priori* the type of relationship between expenditure (or income) and price elasticities.

The second group of demand systems achieved functional forms which are locally flexible. In other words, these demand systems have small regular regions consistent with microeconomic theory where elasticities have no restrictions and can take any value.

In this group of demand systems, the most diffused models with locally flexible functional forms are the Basic Translog (Chriestensen et al., 1975) and the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980).

The Basic Translog can be estimated through the following expenditure share function:

$$w_i = \frac{\alpha_i + \sum_j \beta_{ij} \log\left(\frac{p_j}{m}\right)}{1 + \sum_k \sum_j \beta_{kj} \log\left(\frac{p_j}{m}\right)} \qquad 1$$

Where w_i is the share of expenditure allocated to good i, p_j is the price of the j^{th} commodity and m is the total expenditure; while α and β are parameters to be estimated.

The AIDS model can be derived by log linearly transforming any cost function; therefore it has a flexible functional form. It can be estimated with the following function:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left(\frac{m}{P}\right) \qquad 2$$

Both tranglog and AIDS models guarantee enough parameters to identify elasticities at a given point. However, locally flexible functional forms have small regular regions. Moreover, homogeneity, symmetry and adding-up conditions are not automatically satisfied. Finally, because the Engel-flexibility is limited to linearity in logarithms, these models have limited capacity to capture realistic income responses to price changes.

In order to achieve functional forms with larger regular regions and to allow for more general income responses, alternative models have been developed in the literature. These models, which constitute the second group of demand systems after the LES and Rotterdam models, improved the coherence with demand theory by considering the non-linearity of the Engel's curves.

Some models solved the problem of the non-linearity of Engel's curves by including in the demand function a quadratic term of the relationship between total expenditure and prices. For example, the Quadratic Expenditure System (QES) developed by Howe et al. (1979) is a generalization of the LES and the AIDS which improves the Engel-flexibility:

$$w_i = \frac{p_i\beta_i}{m} + \alpha_i\left(1 - \sum_{j=1}^{n}\frac{p_j\beta_j}{m}\right) + \frac{\left(p_i\gamma_i - \alpha_i\sum_{j=1}^{n}p_j\gamma_j\right)}{m}\prod_{j=1}^{n}p_j^{-2\alpha_j}\left(m - \sum_{j=1}^{n}p_j\beta_j\right)^2 \qquad 3$$

However, the Engel-flexibility in the QES is still quite limited because of the linearity of marginal expenditure. Banks et al. (1997) extended the AIDS with a quadratic term, developing the Quadratic Almost Ideal Demand System (QUAIDS):

$$w_i = \alpha_i + \sum_{j=1}^{n}\gamma_{ij}\log p_j + \beta_i\log\left[\frac{m}{a(p)}\right] + \frac{d_i}{b(p)}\left\{\log\left[\frac{m}{a(p)}\right]\right\}^2 \qquad 4$$

Rimmer and Powell (1996) nested the LES developing the An Implicitly Directly Additive Demand System (AIDADS). On the contrary to QES and QUAIDS the Engel-flexibility is improved by imposing less restrictive marginal expenditure shares:

$$q_i = \gamma_i + \frac{\alpha_i + \beta_i\exp(u)}{1+\exp(u)}\left(m - \sum_{j=1}^{n}p_j\gamma_j\right) \qquad 5$$

Although the second group of models improved the flexibility of functional forms making demand systems more coherent with microeconomic theory, the question of which specification to use is still open and the choice is driven by empirical considerations, such as the level of aggregation of the data at hand.

Usually, different models provide different estimations and models' performance can be different for the estimation of expenditure rather than price elasticities. For example, as mentioned above, when income changes the AIDS model estimation of elasticities is less robust and particularly the income elasticity tends to be smaller as income increases (Abler, 2010).

Therefore, the choice of the right model depends also on the empirical application for which the use is intended. For example, in agricultural applications the use of demand systems is mainly aimed to obtain expenditure rather than price elasticities, as, in the long run, income is considered to be more important than prices for the changes in consumption patterns.

Finally, although the issues related to the coherence with microeconomic theory of the estimation of demand functions have been extensively dealt with, the more recent advancement regarding demand systems are taking into account the potential endogeneity of prices and expenditure.

Endogeneity in demand systems rise mainly because of the way prices are calculated. Commodity prices are often calculated as the ratio between the observed expenditure and quantity consumed. As Deaton (1988) observed, this method of calculating commodity unitary prices reflects market prices, but also the commodity's quality.

This is not the only reason why endogeneity is a common ingredient in demand systems. Others are: i) measurement errors due to infrequent purchases; ii) unobserved commodity's characteristics affecting demand behaviour; iii) unobserved shocks common to prices and expenditure (Blundell and Robin, 1999). All these factors can result in expenditure or prices (or both) correlated with the errors, resulting in biased and inconsistent estimations and in biased shapes of the Engel curves. If there is correlation between prices/expenditure and the error terms, Ordinary Least Squares (OLS) and Seemingly Unrelated Regressions (SUR) provide inconsistent estimators. However, such correlation can be accounted for with instrumental variable and augmented regression techniques (Hausman 1978; Holly and Sargan 1982).

3 Food Security and food demand in Kenya

Achieving 100% food security is part of Kenya's Big Four Presidential Agenda. Food security is a multifaceted concept involving food availability together with food utilisation, stability and access. Most of the analysis related to food demand focus on the supply side issues (agricultural production, food availability, trade) and on issues of declining productivity growth and sustainably increasing agricultural productivity. These are the topics where public policies can have a bigger impact. Ex-ante analyses of policies change are typically produced to simulate impacts of different policies on the overall country food security (Boulanger et al., 2017 and 2018).

However, improving the understanding of the demand-side drivers of food demand patterns and their evolution in respect to changes in income and prices can improve the overall food security analysis (Regmi and Meade, 2013). This is particularly true when food security is studied trough simulations models which rely on exogenous parameters, typically borrowed from the literature, which links changes in demand to changes in income and prices of commodities. This is even more relevant for Computable General Equilibrium (CGE) models in which, given the specific structure, demand and supply are intimately linked and influencing each other. A better representation of food demand patterns and their reaction to economic changes and market signals enables an improvement in the design of food security policies, a better identification of winner and loser groups associated with shocks and allows an improved linked between food and nutrition security.

Understanding the patterns of food consumption in different country regions and in rural and urban areas is a crucial step to study food security. In Kenya, differences between rural and urban households were identified by the 2005/06 household budget survey: for instance urban households source more than 96% of their food from markets, compared to 75% for rural households; spend 10 Kenyan shilling (KSh) more than rural households on purchasing 1 000 Kcal; and spend KSh 28 per person per day more on their daily food consumption than rural households despite their share of food to total-food and non-food expenditure being 36% compared to 58% for rural households (Musyoka et al., 2014). In the current literature a few studies have been dedicated to the analysis of food demand in Kenya.

Urban household food insecurity is a major problem in Kenya. Estimating elasticities of food demand through a Linear Approximated Almost Ideal Demand System (LA/AIDS) Musyoka et al., (2010) found that urban poor are sensitive to variation in food prices and income and they should be cushioned against negative effects of price increase to enhance their access to food and their food security. Dairy and dairy products and wheat and wheat products were identified as subsidy carriers which would improve the nutrition of the urban poor.

Employing a Quadratic Almost Ideal Demand System (QUAIDS) model, Musyoka et al., (2014) provide evidence on how food consumption relates to food prices, household food expenditure, and demographic and regional factors, while also evaluating the welfare impact of reduced import tariffs on three important cereals in Kenya. Authors find that expenditure elasticities are greater than the own-price elasticities in urban and rural areas. Increasing household income and food expenditure through income transfer and creation of on-farm and off-farm employment would improve household food access more than price policies.

Further analysis, involving a QUAIDS demand model household size, find results broadly consistent with the demand theory but add that regional differences, the ratio of food expenditure to total income and the ratio of auto-consumption are statistically significant, and hence have a great impact on food consumption expenditure. Again, increasing the understanding of the potential role of household socio-economic characteristics, food prices and income in explaining food demand in Kenya would improve any policy design to improve food security (Korir et al., 2018).

Additionally, a few studies focused on the meat sector in Kenya using a Linear Approximated Almost Ideal Demand System (LA/AIDS). There is evidence of substitution between meat products (Shibia et al., 2017), with indigenous chicken substituting for beef, mutton for beef, indigenous chicken and goat meats. The models suggest that mutton/goat is a necessity good while bone beef and chicken are luxury goods (Shibia et al., 2017). These estimates are necessary in targeting the meat industry to improve the national meat production, satisfying the local consumption and obtaining surplus for exports (Bett et al., 2012).

4 Model and estimation method

For the estimation of demand elasticities parameters using household survey data from Kenya the best strategy is to apply QUAIDS (Banks et la., 1997). The choice of QUAIDS is based on its flexible functional form which allows coherence with demand and consumer behaviour theory, and the possibility to account for the endogeneity between prices and expenditure.

Consider the following demand system in vector notation, which is the Banks et al. (1997) quadratic extension of the Deaton and Muellbauer's (1980) AIDS model:

$$w_i^h = \alpha_i + \gamma_i' p^h + \beta_i \{x^h - a(p^h, \theta)\} + \lambda_i \frac{\{x^h - a(p^h, \theta)\}^2}{b(p^h, \theta)} + u_i^h \qquad 6$$

where w^h_i is the expenditure share of good $i = 1, \ldots, N$ for household $h = 1, \ldots, H$; x^h is the household's total expenditure; $\boldsymbol{p}$ is a vector of prices; u is the error term; and $\alpha, \beta, \gamma, \theta$ are the parameters to be estimated. a and b are non-linear price aggregator functions defined as:

$$a(p^h, \theta) = \alpha_0 + \alpha' p^h + \frac{1}{2} p^{h\prime} \gamma p^h \qquad 7$$

$$b(p^h, \theta) = \exp(\beta' p^h) \qquad 8$$

The parameters $\alpha, \beta, \gamma, \theta$ must satisfy the theoretical restrictions of additivity, homogeneity and symmetry, which are:

$$\sum_{i=1}^{n} \alpha_i = 1; \quad \sum_{i=1}^{n} \beta_i = 0; \quad \sum_{j=1}^{n} \gamma_{ij} = 0; \quad \sum_{i=1}^{n} \lambda_i = 0; \quad \text{and } \gamma_{ij} = \gamma_{ji} \qquad 9$$

Equation (6) can be estimated with different estimators. A common approach is using seemingly unrelated regressions (SUR) with iterated feasible generalized nonlinear least-squares estimator (FGNLS) through nonlinear three-stage least squares (Poi, 2012), which allows the computation of expenditure and price elasticities controlling for households' heterogeneity. However, the main shortcoming of FGNLS is that non-linear least-squares are computationally demanding when a large number of parameters have to be estimated. This is a common situation when dealing with large and highly disaggregated consumption datasets with multiple goods. Moreover, the approach proposed by Poi (2012) does not address endogeneity.

A preferred alternative is the approach proposed by Lecocq and Robin (2015) to use the Iterated Linear Least-Squares (ILLS) estimator developed by Browning and Meghir (1991) and later generalized by Blundell and Robin (1999).

This approach is computationally attractive. It is based on the conditional linearity property – i.e. all equations in (6) are linear in all parameters conditional on the price aggregators functions – and it requires linear SUR to obtain consistent and asymptotically normal estimation of the demand system.

In the Lecocq and Robin's model (2015) the demographic variables to control for household heterogeneity are included through the translating approach. This approach allows to vary the level of demand according to household characteristics, by parametrizing the intercepts α's with sociodemographic variables s^h from the household survey, such that:

$$\alpha^h = As^h; A = (\alpha_i') \qquad 10$$

Lecocq and Robin's model (2015) allows accounting for endogenous prices and total expenditure by using instrumental variable techniques. The error u^h_i is augmented with the error vector $\boldsymbol{v}^h$ predicted from estimating reduced forms for x^h and $\boldsymbol{p}^h$:

$$u_i^h = \rho_i \widehat{V}^h + \varepsilon_i^h \qquad 11$$

The independent variables in the reduced form equations are the sociodemographic variables in s^h and the proper identifying instruments.

Finally, obtaining estimates of expenditure and price (compensated and uncompensated) elasticities is the main objective of this analysis. In Lecocq and Robin (2015) elasticities are calculated at the mean of the household sample.

5 Data and empirical strategy

The main source of data is the Kenya Integrated Household Budget Survey 2005/06 (KIHBS 05/06). This survey covered all the 70 districts of the country, including rural and urban clusters. KIHBS used both diary and recall methods in collecting household consumption and purchase information. Specifically, the KIHBS was designed to update and strengthen three vital aspects of the national statistical database, notably: the Consumer Price Index (CPI), poverty and inequality; and the System of National Accounts (SNA). The data collection phase of this survey took 12 months and data on demographics, housing, education, health, agriculture and livestock, enterprises, expenditure and consumption, among others, was collected.

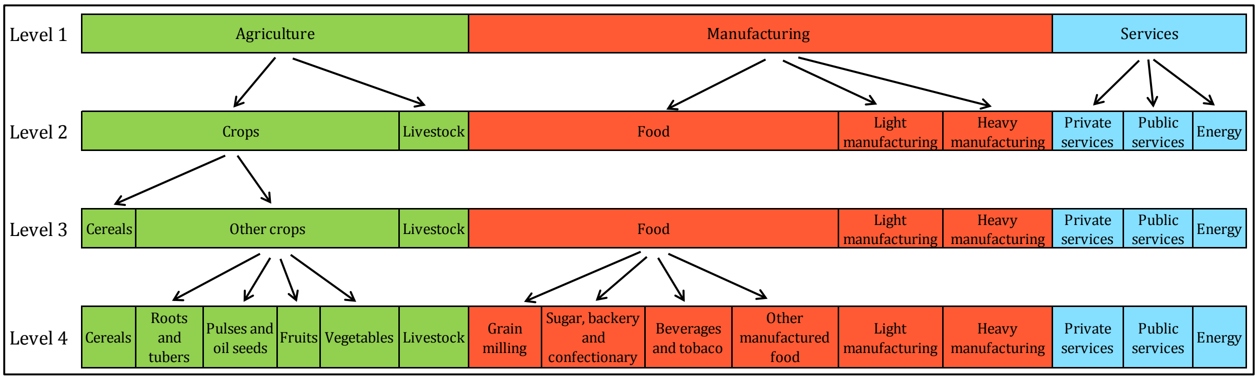
The Survey was conducted in 1,343 randomly selected clusters across all districts in Kenya and comprised 861 rural and 482 urban clusters. 10 households were randomly selected with equal probability in each cluster resulting in a total sample size of 13,430 households, allocated into 136 explicit strata: the urban and rural areas of all districts except Nairobi and Mombasa, which are entirely urban. However, in the six districts that contain municipalities, clusters in the urban sample were further stratified into six groups: five socio-economic classes in the municipality itself and other urban areas in the district. This ensured that different types of neighbourhoods and social classes within municipal areas are all represented in the sample. The total sample sizes in rural and urban areas were 8,610 and 4,820 households respectively.

The year-long survey was organised into 17 cycles of 21 days each, during which enumerators conducted household interviews in the clusters.

Using the KIHBS 2005/06 data, demand systems have been estimated with ILLS (Lecocq and Robin, 2015) for different levels of goods' aggregation. Four levels of aggregation are used, from 1 (more aggregated) to 4 (less aggregated Figure 1).

Level 1 is the most aggregated, consisting of three types of goods: agriculture, manufacturing and services. Level 2 splits agriculture in crops and livestock; manufacturing in food, light and heavy manufacturing; and services in public, private services and energy. Level 3 further splits crops in cereals and other crops. Level 4 is the most disaggregated, consisting of a total of 15 different goods.

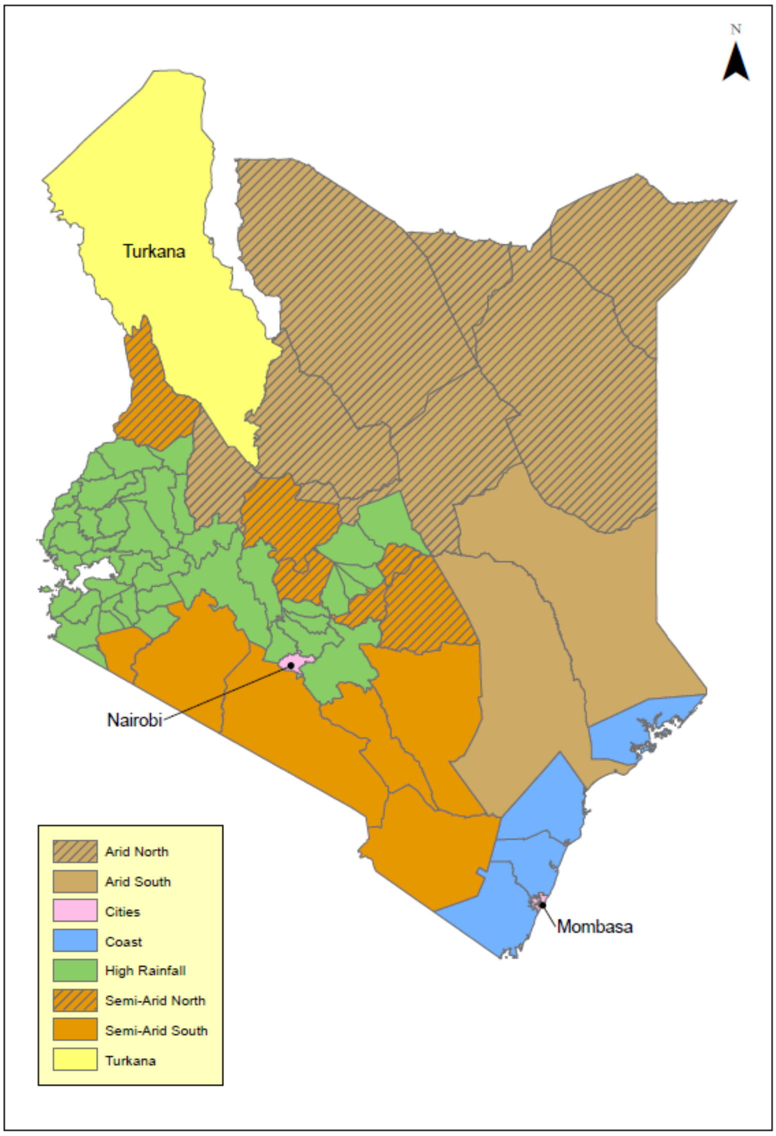
Figure 1– Aggregation levels of goods



The choice of the aggregation levels is data driven. For each good, expenditure shares (w^h_i) are calculated from the survey data as expenditure of good *i* on total household expenditure, so that $\sum_{i=1}^{n} w_i^h = 1$. Prices are calculated as consumed quantity of good *i* on expenditure of good *i* in the latest week. Given that not all goods have been consumed or purchased by all households during the latest week, the fourth is the most disaggregated level achievable that provides meaningful price values for the majority of the households.

The demand system estimation is corrected for household heterogeneity, by parametrizing the intercepts $\boldsymbol{a}^h$ with a vector of variables $\boldsymbol{s}^h$. These variables are: household size, gender, education and age of the head of the household (see Table 1 for definitions). In addition, a series of regional dummy variables are included to control for potential heterogeneity of agro-ecological conditions of the households. The regions are defined and mapped in Figure 2.

Figure 2 – Agro-ecological zones (AEZs) of Kenya



For the analysis, Kenya has been divided into six Agro Ecological Zone (AEZs), in addition to the Turkana region and two major metropolises, i.e., Nairobi and Mombasa (Mainar et al., 2018) (see Table A1 in the Annex). Based on previous studies (Mabiso et al., 2012; Thurlow and Benin, 2008; Kiringai et al.,2006) and own assumptions, these AEZs distinguish the characteristics of the primary sector production in different regions of the country, enabling specific analysis of the effects of different policies focusing on territories, products or specific activities. The nine regions considered are (i) Nairobi, (ii) Mombasa, (iii) High Rainfall, (iv) Semi-Arid North, (v) Semi-Arid South, (vi) Coast, (vii) Arid North, (viii) Arid South and (ix) Turkana.

Moreover, in order to verify if differences in consumption patterns exist between different types of households, the estimations are done also dividing the households in two subsamples: rural and urban households.

In order to control for potential endogeneity of expenditure and prices, instrumental variable techniques have been used. Specifically, expenditure is instrumented using the amount of payments received for salaries or wages. On the contrary prices are instrumented with the price adjusted with the aggregate consumer price index (2009 is the baseline year) provided by the Kenya Bureau of Statistics.

Table 1 – Definition and sample average of demographic variables

Variable	Definition	Mean
HH size	Number of households members in adult equivalent	3.999
Gender	=1 if head of the HH is a woman; 0 otherwise	0.297
Education	=1 if the household head has no formal education; 0 otherwise	0.317
Age	Age of the household head in year	44.537
Pay	Payment for wages/salaries in the last week (logarithm)	3.928

6 Results and Discussion

The main objective of estimating the QUAIDS in equation (6) is to obtain expenditure and price elasticities for goods consumed by households in Kenya. All estimations are conducted with instrumental variables techniques to control for the potential endogeneity of both expenditure and prices. Moreover, all estimations include socio-demographic variables to control for households heterogeneity (Table 1).

Table 2 shows the results of estimated elasticities for Level 1 goods – i.e. agriculture, manufacturing and services goods. The first column reports the results of expenditure elasticities – i.e. the coefficient represents the change in demand corresponding to a change in income. The second column reports the uncompensated price elasticities derived from ordinary (Marshallian) demand curves – i.e. the coefficient represents the change in demand corresponding to a change in good's price which affects the disposable income. The third column reports the compensated price elasticities which measure substitution effects between goods – i.e. the coefficient represents the change in demand corresponding to a change in good's price, ignoring the income effect.

Looking at the expenditure elasticities for the whole sample of households in Table 2, the first aspect worth noting is that values are close to the unitary income elasticity of demand (=1), suggesting that any increase in expenditure is almost proportionate to increases in the quantity demanded. However, two different patterns emerged. The expenditure elasticity of agricultural goods is significantly higher than 1, suggesting that agricultural products are superior goods and slightly more luxurious than manufacturing goods and services of which elasticities are significantly lower 1.

This is also confirmed in column two, where agricultural goods show a greater responsiveness to price changes (uncompensated price elasticity above 1 in absolute terms). On the contrary, manufacturing and services, which are necessity goods, are inelastic to price changes. This suggests that for Kenyan households if agricultural goods prices increase the corresponding reduction in agricultural goods demand is quite large (more than proportional), while if manufacturing or services prices increase their demand change is quite small (less than proportional). However, the low compensated price elasticity of all three goods suggests that their substitution effect is low.

Table 2 – Elasticities estimates of Level 1 goods

	All Households			Rural Households			Urban Households		
	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price
Agriculture	1.013***	-1.007***	-0.613***	0.999***	-0.989***	-0.582***	1.028***	-1.014***	-0.645***
se	0.012	0.01	0.01	0.016	0.012	0.012	0.018	0.017	0.016
Manufacturing	0.997***	-0.987***	-0.556***	1.004***	-0.993***	-0.555***	0.996***	-0.996***	-0.571***
se	0.01	0.014	0.013	0.014	0.014	0.013	0.013	0.017	0.016
Services	0.979***	-0.972***	-0.797***	0.992***	-0.993***	-0.838***	0.961***	-0.923***	-0.717***
se	0.023	0.024	0.024	0.038	0.031	0.029	0.028	0.028	0.028
N. Obs.	8839			5478			3361		

However, expenditure elasticities of agricultural and manufacturing goods are different for rural and urban households. In urban areas, results do not change with respect the whole sample. On the contrary, in rural areas agricultural goods turn necessity goods (below 1) and manufacturing goods turn superior goods (above 1). This suggests that the consumption patterns and income levels are quite different between urban and rural households. Rural households are probably more likely to have access to (locally and/or household produced) raw agricultural food, while urban households to manufactured foods. Manufactured industrialized food is probably cheaper in urban areas, but in the same time it has lower quality and it is nutritionally less valuable than agricultural products, such as vegetables and fruits. Therefore, at increasing income level of urban households the consumption of higher quality, healthy agricultural products also increases.

The fact that agricultural goods are superior goods is an interesting and unexpected result, and it can have different interpretations. On the one hand, higher quality agricultural goods can be more expensive in urban areas and less affordable if income does not increase. On the second hand, in rural areas accessibility to agricultural goods is higher than in the cities and there is not much alternative towards more differentiate manufactured food, therefore agricultural goods are necessity goods because of higher accessibility and lower possibilities of diversification into manufactured food.

This suggests that agricultural goods should not be interpreted as "luxury" goods in absolute terms, but in comparative terms with other food groups. In other words, the trade-off between consuming agricultural raw foods instead of manufacture food does not depend exclusively on the available income as in the case of jewellery or luxury cars; instead it depends also on the availability and access of alternative food sources. Therefore, these results should be interpreted taking into account wider food security considerations.

It is possible to better understand the patterns in Table 2 by looking at the second level of aggregation where each group of goods is further detailed. Looking at the expenditure elasticities of all households in Table 3, it looks clear that manufactured food, private services and energy are necessity goods, while all the others are superior goods.

Table 3 – Elasticities estimates of Level 2 goods

	All Households			Rural Households			Urban Households		
	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price
Crop	1.043***	-0.999***	-0.738***	1.052***	-0.986***	-0.690***	1.038***	-0.959***	-0.734***
se	0.025	0.015	0.014	0.031	0.018	0.017	0.042	0.025	0.021
Livestock	1.049***	-1.008***	-0.858***	0.986***	-1.017***	-0.879***	1.117***	-1.010***	-0.818***
se	0.027	0.008	0.008	0.039	0.009	0.01	0.037	0.012	0.012
Food	0.987***	-1.006***	-0.829***	0.987***	-1.013***	-0.828***	1.005***	-0.994***	-0.831***
se	0.028	0.015	0.014	0.036	0.016	0.016	0.057	0.025	0.025
Light manufacturing	1.002***	-0.967***	-0.864***	0.991***	-0.984***	-0.882***	1.076***	-0.944***	-0.835***
se	0.044	0.031	0.03	0.062	0.032	0.031	0.071	0.043	0.041
Heavy manufacturing	1.005***	-0.979***	-0.878***	1.059***	-1.015***	-0.907***	0.910***	-1.001***	-0.914***
se	0.033	0.037	0.038	0.043	0.026	0.027	0.061	0.048	0.048
Private services	0.963***	-0.924***	-0.837***	0.737***	-0.968***	-0.919***	0.818***	-0.855***	-0.769***
se	0.048	0.033	0.033	0.092	0.043	0.042	0.08	0.048	0.049
Public services	1.032***	-1.021***	-0.933***	1.116***	-1.018***	-0.927***	1.171***	-1.004***	-0.897***
se	0.058	0.036	0.034	0.083	0.051	0.047	0.09	0.044	0.043
Energy	0.674***	-0.940***	-0.908***	0.806***	-1.046***	-1.016***	0.530***	-0.896***	-0.868***
se	0.05	0.041	0.04	0.082	0.035	0.034	0.083	0.057	0.055
N. Obs.	8839			5478			3361		

It is worth noting the difference in expenditure elasticity between manufactured food and agricultural goods in Table 3. For households in Kenya, manufacture foods are a necessity good for nutrition, but not crops and livestock which are superior goods. This is not surprising given the fact that fresh agricultural products can be more expensive and more valuable for trade rather than self-consumption, while manufactured food has lower value and it is purchased to satisfy nutritional needs. In other words, this suggests that agricultural products, either crops or livestock, are luxurious goods while food products are necessity goods.

However, the uncompensated price elasticity of crop, livestock and food is very close to the unitary value, suggesting that changes in prices correspond to almost proportionate changes in demand for these goods; therefore their utility is almost maximized.

Within manufacturing goods in Table 3, there is a net difference between food (necessity good) and light and heavy manufacturing (superior goods). Within services, energy has the lower expenditure elasticity, suggesting that energy is a key element for the subsistence of the household in Kenya. On the contrary, it is striking that public services, which include basic services such as health and education, are luxury goods.

Once again, it is important to observe the differences between rural and urban households, whose consumption patterns can be significantly different in Table 3. More specifically, livestock products are necessity goods in rural areas, as well as light manufacturing. In urban areas, heavy manufacturing turns to necessity goods.

Moving to the next level of aggregation in Table 4, the patterns emerged in Table 3 are confirmed. Agricultural products are superior goods with low level of price substitution, while manufactured foods are necessity goods. However, it is interesting to note that other crops different to cereals are inelastic to price changes, suggesting that despite they are necessity goods, their demand is not affected by prices. Energy is confirmed to be the most indispensable service.

Table 4 – Elasticities estimates of Level 3 goods

	All Households			Rural Households			Urban Households		
	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price
Cereals	1.055***	-1.005***	-0.877***	1.058***	-1.029***	-0.873***	1.050***	-0.936***	-0.849***
se	0.043	0.03	0.028	0.057	0.038	0.033	0.075	0.044	0.041
Other crops	1.025***	-0.996***	-0.863***	1.063***	-1.008***	-0.865***	1.002***	-0.970***	-0.835***
se	0.03	0.014	0.013	0.043	0.017	0.016	0.047	0.022	0.02
Livestock	1.050***	-1.004***	-0.854***	0.988***	-1.015***	-0.876***	1.107***	-1.006***	-0.813***
se	0.029	0.008	0.009	0.044	0.009	0.011	0.04	0.011	0.013
Food	0.983***	-1.005***	-0.828***	0.973***	-1.013***	-0.831***	1.011***	-0.989***	-0.825***
se	0.03	0.015	0.015	0.041	0.016	0.018	0.062	0.025	0.027
Light manufacturing	0.999***	-0.968***	-0.865***	0.981***	-0.984***	-0.883***	1.065***	-0.950***	-0.841***
se	0.048	0.031	0.031	0.071	0.033	0.032	0.077	0.043	0.042
Heavy manufacturing	1.009***	-0.974***	-0.872***	1.068***	-1.014***	-0.905***	0.897***	-0.995***	-0.909***
se	0.035	0.038	0.038	0.049	0.026	0.027	0.066	0.048	0.049
Private services	0.955***	-0.920***	-0.834***	0.700***	-0.966***	-0.920***	0.839***	-0.852***	-0.765***
se	0.052	0.033	0.034	0.109	0.045	0.044	0.088	0.049	0.049
Public services	1.044***	-1.017***	-0.928***	1.126***	-1.003***	-0.911***	1.216***	-0.998***	-0.888***
se	0.063	0.037	0.035	0.094	0.051	0.048	0.1	0.045	0.045
Energy	0.692***	-0.928***	-0.896***	0.847***	-1.046***	-1.015***	0.530***	-0.883***	-0.855***
se	0.055	0.042	0.041	0.095	0.037	0.036	0.09	0.058	0.056
N. Obs.	8839			5478			3361		

The main differences between rural and urban households are observed in the livestock, food, light manufacturing and heavy manufacturing goods in Table 4. Among agricultural goods, in rural areas livestock products are necessity goods.

By further digging into the most disaggregated level of the estimations (Table 5), it is clear that, within agricultural goods roots and tubers are a necessity good for households in Kenya with low demand responsiveness to changes in prices and low substitution effect. On the contrary, pulses and oilseeds as well as fresh vegetables, which are important sources of proteins and nutrients, are luxury goods, with lower price responsiveness and higher substitution effect than the previous agricultural goods.

Among manufactured foods, milled grains and other foods are necessity goods with lower price responsiveness and substitution effect, but beverages and tobacco as well as sugary and confectionary food products are luxury goods.

Also in the level 4 estimations (Table 5), it is striking noticing that basic public services expenditure elasticity is much higher than private ones and, especially, energy. Public services responsiveness to changes in prices is significantly greater than one, suggesting that when the cost of education and health rise, their demand drops, almost as if they are not necessary as much as other services such as energy, transports and communication.

Table 5– Elasticities estimates of Level 4 goods

	All Households			Rural Households			Urban Households		
	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price	Budget	Unc. price	Comp. price
Cereals	1.056***	-0.996***	-0.873***	1.050***	-1.014***	-0.861***	1.032***	-0.937***	-0.846***
se	0.062	0.033	0.03	0.082	0.041	0.034	0.089	0.041	0.039
Roots and tubers	0.824***	-0.893***	-0.875***	0.914***	-0.836***	-0.817***	1.007***	-0.936***	-0.911***
se	0.102	0.036	0.036	0.169	0.055	0.054	0.141	0.046	0.045
Pulses and oil seeds	1.136***	-0.962***	-0.931***	1.176***	-0.964***	-0.922***	1.052***	-1.014***	-0.991***
se	0.107	0.034	0.034	0.131	0.047	0.045	0.135	0.034	0.034
Fruits	1.036***	-0.920***	-0.902***	1.145***	-1.048***	-1.032***	0.949***	-0.925***	-0.897***
se	0.088	0.032	0.032	0.138	0.041	0.041	0.106	0.035	0.034
Vegetables	1.115***	-0.994***	-0.932***	1.085***	-1.018***	-0.953***	1.133***	-1.023***	-0.958***
se	0.058	0.02	0.019	0.082	0.024	0.023	0.086	0.031	0.029
Livestock	1.013***	-1.011***	-0.871***	0.888***	-1.016***	-0.895***	1.084***	-1.076***	-0.899***
se	0.04	0.008	0.01	0.066	0.009	0.014	0.059	0.02	0.015
Grain milling	0.827***	-0.707***	-0.694***	0.827***	-0.752***	-0.737***	1.017*	-0.28	-0.276
se	0.143	0.056	0.055	0.221	0.075	0.072	0.478	0.213	0.213
Sugar, backery, confectionary	1.001***	-0.969***	-0.887***	0.963***	-0.949***	-0.861***	1.057***	-0.984***	-0.906***
se	0.05	0.009	0.01	0.072	0.011	0.013	0.076	0.016	0.015
Beverages & tobacco	1.000***	-0.917***	-0.873***	1.082***	-0.966***	-0.915***	1.155***	-0.855***	-0.812***
se	0.102	0.018	0.018	0.127	0.019	0.017	0.22	0.039	0.041
Other manufactured food	0.965***	-0.891***	-0.855***	0.995***	-0.959***	-0.931***	1.180***	-0.865***	-0.817***
	0.115	0.034	0.034	0.159	0.016	0.015	0.252	0.081	0.086
Light manufacturing	1.006***	-0.958***	-0.855***	1.003***	-0.983***	-0.878***	1.050***	-0.938***	-0.832***
se	0.068	0.032	0.032	0.101	0.033	0.036	0.104	0.047	0.045
Heavy manufacturing	1.084***	-0.959***	-0.847***	1.078***	-1.009***	-0.897***	0.961***	-0.990***	-0.892***
se	0.048	0.037	0.037	0.069	0.026	0.026	0.084	0.047	0.047
Private services	0.908***	-0.941***	-0.854***	0.659***	-0.981***	-0.936***	0.796***	-0.908***	-0.820***
se	0.064	0.032	0.033	0.14	0.043	0.042	0.102	0.055	0.059

Public services	1.014***	-1.022***	-0.930***	1.177***	-1.031***	-0.933***	1.108***	-1.006***	-0.911***
se	0.084	0.035	0.033	0.131	0.053	0.05	0.142	0.045	0.045
Energy	0.751***	-0.958***	-0.919***	0.992***	-1.042***	-1.001***	0.536***	-0.966***	-0.933***
se	0.067	0.038	0.037	0.12	0.034	0.033	0.09	0.048	0.046
N. Obs.	8839			5478			3361		

Finally, elasticities have been also estimated for each region in the sample (Figure 2). Estimations at regional level are done for Level 1 of commodities aggregation only, because of data constraints, such as the low number of observations in some of the regions. These constraints do not allow consistent estimations with homogeneity and symmetry restrictions. Results of regional elasticities are shown in Table 6

Table 6 – Regional elasticities estimates of Level 1 goods

		Expenditure elasticity	Uncompensated price elasticity	Compensated pri elasticity
	Agriculture	0.919***	-0.961***	-0.625***
	se	0.073	0.043	0.038
	Manufacturing	1.081***	-1.149***	-0.620***
Arid North	se	0.053	0.056	0.061
	Services	0.931***	-1.301***	-1.167***
	se	0.16	0.116	0.125
	Obs.	307		
	Agriculture	1.095***	-1.137***	-0.498***
	se	0.047	0.043	0.053
	Manufacturing	0.925***	-1.113***	-0.770***
Arid South	se	0.072	0.067	0.089
	Services	0.377	-0.6	-0.584
	se	0.824	0.715	0.678
	Obs.	77		
	Agriculture	1.049***	-1.047***	-0.598***
	se	0.063	0.042	0.034
	Manufacturing	0.936***	-0.971***	-0.551***
Coast	se	0.05	0.03	0.031
	Services	1.064***	-1.024***	-0.894***
	se	0.165	0.116	0.106
	Obs.	398		
	Agriculture	1.014***	-0.983***	-0.590***
	se	0.016	0.012	0.012
	Manufacturing	1.008***	-0.988***	-0.553***
High Rainfall	se	0.013	0.014	0.012
	Services	0.951***	-0.920***	-0.747***
	se	0.032	0.026	0.026
	Obs.	5,646		
	Agriculture	0.916***	-0.973***	-0.608***
	se	0.057	0.039	0.033
	Manufacturing	1.082***	-1.000***	-0.541***
Semi-arid North	se	0.048	0.053	0.051
	Services	0.992***	-1.093***	-0.916***
	se	0.111	0.065	0.059
	Obs.	919		
	Agriculture	0.992***	-1.157***	-0.643***
	se	0.044	0.06	0.024
	Manufacturing	0.823***	-0.991***	-0.733***
Semi-arid South	se	0.091	0.065	0.078
	Services	1.357***	-0.852***	-0.624***
	se	0.061	0.084	0.126
	Obs.	674		
	Agriculture	0.690*	-0.7	-0.426
	se	0.296	0.397	0.227
	Manufacturing	1.229***	-0.926***	-0.211
Turkana	se	0.111	0.149	0.333
	Services	0.545	-0.83	-0.818
	se	1.596	0.709	0.661
	Obs.	75		
	Agriculture	1.052***	-0.984***	-0.636***
	se	0.076	0.07	0.062
	Manufacturing	0.974***	-1.003***	-0.568***
Mombasa	se	0.046	0.027	0.029
	Services	0.974***	-0.951***	-0.735***
	se	0.105	0.053	0.054
	Obs.	184		
Nairobi	Agriculture	1.015***	-1.053***	-0.786***

se	0.062	0.077	0.088
Manufacturing	0.970***	-1.008***	-0.595***
se	0.03	0.026	0.031
Services	1.028***	-0.996***	-0.676***
se	0.053	0.041	0.037
Obs.	559		

Elasticities at regional level show some interesting differences with respect to Table 2. First of all, all expenditure elasticities coefficients are statistically significant with the exceptions of services in the arid south and Turkana regions. This is probably due to data constraints as these are the regions with the lower number of observations.

Second, while at the sample average agricultural and manufacturing goods are luxury and necessity goods respectively (Table 2), this is reverted in the arid north, semi-arid north and Turkana regions which have relatively higher poverty ratios.

Third, in the high rainfall region both agriculture and manufacturing goods are luxury goods, while in the semi-arid south region they are both necessity goods. It is possible that high rain-fall region has relatively more favourable conditions for agricultural production which allows households to consume more of their own produce which in turn makes the consumption of agricultural commodities from the market a luxury good. On the other hand, the regions with less favourable conditions for agricultural production rely more on agricultural commodities purchased from the market, making them necessity goods.

Forth, services are necessity goods in the arid north, high rainfall, semi-arid north and Mombasa regions. This is the opposite than the sample average where services are luxury goods.

Finally, the main difference between the urban regions of Mombasa and Nairobi is in services which are necessity goods in the first and luxury goods in the latter.

7 Conclusions and policy recommendations

The aim of this study is the estimation of the income and price elasticities of different commodities consumed by the Kenyan households. Employing the Kenya Household Budget Survey for 2005-2006, we estimate a QUAIDS approach which has a flexible functional form that allows coherence with demand and consumer behaviour theory, and accounts for the endogeneity between prices and expenditure. We perform the estimations for 4 different levels of commodity grouping and also at the regional level.

Estimations yield significant income and price elasticities at all levels. Roots and tubers in the agricultural commodities; grain milling in processed food products and energy and private services in services found to be necessity goods (i.e. their income elasticities are below one) while almost all other commodities have unit elastic income elasticities.

Estimated uncompensated price elasticities suggest that demand for root and tubers, grain milling and other manufactured commodities are inelastic while almost all other commodities have a unit elastic demand. However, when the income effect is eliminated demand for almost all commodities become inelastic. The difference between compensated and uncompensated demand elasticities suggest that income effect is small for agricultural commodities except cereals as well as for the 'other manufactured food commodities' (i.e. the effect of the change in disposable income due to the changes in the prices of these commodities on the demand is rather small). The income effect is significant for all other commodities suggesting a higher share in the consumption basket. Another important finding is the significantly lower income elasticity of energy signalling the importance of energy for the Kenyan household subsistence.

Regional differences in income and price elasticities suggests that regions with less favourable conditions for agricultural production rely more on the supply of main food staples from the markets and hence have a lower income and price elasticity for these commodities. However, in the regions which have more favourable agricultural production conditions, a larger share of the agricultural consumption comes from the households' own production and hence makes the agricultural products purchased from the market rather 'superior' goods. In that respect, availability and accessibility of food staples in the markets is likely to be a key component of food security, especially in semi-arid regions, Arid North and Turkana.

Finally, the income elasticity of agricultural commodities in the larger cities (i.e. Mombasa and Nairobi) is found to be higher than one. However, the differences between compensated and uncompensated price elasticities are quite significant for these two regions implying the importance of the effect of changing prices through their impact on disposable income. This is mostly due to the reliance of the households in urban regions on the supply of food staples from the market and hence higher budget share for agricultural commodities in the consumption basket of these households.

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List of abbreviations and definitions

AEZ	Agro Ecological Zone
AIDADS	An Implicitly Directly Additive Demand System
AIDS	Almost Ideal Demand System
CGE	Computable General Equilibrium
CPI	Consumer Price Index
DEMETRA	Dynamic Equilibrium Model of Economic Development, Resources and Agriculture
DEVCO	Directorate-General for International Cooperation and Development – EuropeAid
DG JRC	Directorate-General Joint research Centre
ILLS	Iterated Linear Least-Squares
KIHBS	Kenya Integrated Household Budget Survey
Khs	Kenyan shilling
LA/AIDS	Linear Approximated Almost Ideal Demand System
LES	Linear Expenditure System
OLS	Ordinary Least Squares
QUAIDS	QUadratic Almost Ideal Demand System
QES	Quadratic Expenditure System
SNA	System of National Accounts
SUR	Seemingly Unrelated Regressions

List of figures

List of tables

Annexes

Annex 1. Regional breakdown

Table A1. Districts of Kenya by Agro Ecological Zones

Nairobi	Mombasa	High Rainfall		Semi-Arid North	Semi-Arid South	Coast	Arid North	Arid South	Turkana
Nairobi	Mombasa	Kiambu	Bondo	Nyeri	Taita Taveta	Kilifi	Tana River	Tana River	Turkana
		Kirinyaga	Nyando	Mbeere	Kitui	Kwale	Garissa	Garissa	
		Muranga	Bomet	Mwingi	Makueni	Lamu	Moyale		
		Nyandarua	Keiyo	Nyambene	Kajiado	Malindi	Mandera		
		Thika	Kericho	Tharaka	Narok		Wajir		
		Maragua	Koibatek	Laikipia	Trans Mara		Baringo		
		Embu	Marakwet	West Pokot			Samburu		
		Machakos	Nakuru						
		Meru Central	Nandi						
		Meru South	Trans Nzoia						
		Gucha	Uasin Gishu						
		Homa Bay	Buret						
		Kisii	Bungoma						
		Kisumu	Busia						
		Kuria	Mt. Elgon						
		Migori	Kakamega						
		Nyamira	Lugari						
		Rachuonyo	Teso						
		Siaya	Vihiga						
		Suba	Butere/Mumias						

Source: Own elaboration.

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