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John Macharia, Gracious Diiro, John R. Busienei, Kimpei Munei, Hippolyte Affognon, Sunday Ekesi, Menale Kassie, Beatrice Muriithi, Dorothy Nakimbugwe, and Komi Fiaboe

Invited paper presented at the 5th International Conference of the African Association of Agricultural Economists, September 23-26, 2016, Addis Ababa, Ethiopia

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[1,2]John Macharia, [2,3]Gracious Diiro, [1]John R. Busienei, [1]Kimpei Munei [2]Hippolyte Affognon, [2]Sunday Ekesi, [2]Menale Kassie [2]Beatrice Muriithi, [3]Dorothy Nakimbugwe, and [2]Komi Fiaboe

[1]Department of Agricultural Economics, University of Nairobi, PO Box 29053, Nairobi, Kenya; [2]International Centre for Insect Physiology and Ecology (ICIPE), PO Box 30772-00100, Nairobi, Kenya

3 Makerere University, Kampala Uganda

Abstract

The objective of this paper was to estimate the demand for poultry feed among smallholder farmers in Kenya disaggregated by gender. Most poultry enterprises are owned and managed by women even in male headed households. The study utilizes cross-section data collected in July 2015 from a sample 386 poultry farmers randomly selected from three counties including Nakuru, Kisii and Kirinyaga Counties. The feed demand for poultry enterprise was analyzed by estimating a translog cost function and a system of cost share functions for the major feed types used for poultry feeding in Kenya. These include grains, vegetables, and mixed feed. From the study the mean demand of feed per farmer were 55.47 kilograms for grains, 48.37 kilograms for vegetables and 71 kilograms for mixed feed. The variations between male and female farmers were significant at 10% for vegetables. Also the mean costs of feed per farmer were Kshs. 2108.00 for grains, Kshs.1248.00 for vegetables and Kshs 16,214.00 for mixed feed. In addition the results show that feeds are generally price inelastic and price elasticities tend to decrease with rising expenditure level. The study found out that most of the feeds have complementary relationships. For instance grain and mixed feed pair, and vegetable and mixed feed pair all exhibit a complementary relationship.

It is therefore recommended that policy makers should develop policies that aim at reducing the prices of manufactured feed through the adoption of alternative ingredients such as insect as a source of protein in feed manufacture.

KEYWORDS: poultry feed, mixed feed demand, translog cost function,

1. Introduction

Development of the livestock sector is viewed as one of important pathways for reducing poverty and improving food security in many household in many developing countries (Thorntorn, 2010; FAO 2012). In Kenya poultry farming are major subsectors contributing to both income and food security of many households in the country, particularly those residing in the rural areas. The poultry sub-sector contributes about 30 percent to the national Agricultural GDP and about 7.8 percent to the Total GDP (Omiti and Okuthe, 2009). Women have been reported to be the predominant owners of poultry especially free ranging indigenous birds due to its minimum expenditure on feed (Kitalyi 1998 ; Okitoi et al 2007). Although income generated from smallholder poultry farmers is small it is controlled by women and it can provide positive spiral events that will lead the women and rural households out of poverty (Jensen and Dolberg, 2003). Moreover, given that women an integral part of farming households who bear most of the responsibilities for household food security and income, interventions aimed at improving their capacity to produce poultry will play a great role in meeting food demand (Jensen and Dolberg, 2003).

Research indicates that despite the benefits derived from poultry farming, the subsector faces several constraints that hinder full realization of the potential of the enterprise. These constarints are not gender specific but cut across. The most important constraint faced by smallholder farmers especially women and female headed households is inadequate access to affordable feed for poultry (Akinrotimi *et al.,* 2011). Research indicates that feed costs accounts for over 70% of the production costs making it critical for successful poultry production (Craig and Helfrich, 2002; Mwanzia, 2010; Munguti and Charo-Karisa, 2011). High cost of feed is attributed to the

high cost of ingredients used to manufacture feeds. Notably, key ingredients in feed manufacture include fish and soy which are also used as human food resulting to food-feed competition thereby increasing the price of the ingredients (Gitonga, 2014). High and fluctuating prices of poultry feed hamper sustained supply of the products to the market and domestic consumption; because farmers are forced abandon the enterprises due to increased cost of production and reduction (Bett *et al.,* 2015). Women whose role revolve around the homestead chores end up facing tough decisions of whether to rear poultry to provide essential protein or purchase food for the family.

As a result, sustained production and supply of livestock products in Kenya require gendered policy interventions that aim at restructuring the feed subsector to supply smallholder farmers with affordable and cost effective feed for poultry. Understanding the status and the determinants of feed demand for poultry disaggregated by gender will provide policy makers important information for formulation of policy interventions and programs to develop a more sustainable feed subsector for the different genders in the country.

However, empirical studies on gendered feed demand are scarce in Kenya, as in other developing countries. Available studies indicate that the demand for feed in Kenya is not disaggregated especially by gender. These studies also have not exclusively focused on feed but cover the wide area of production inputs. For instance, Kavoi *et al* (2009) did a study to analyze the determinants of the production structure and derived demand for factor inputs in smallholder dairying which focused on scale economies and overall input elasticities. In another study Mbugua (2014) analyzed demand for antibiotics in poultry production with the aim of estimating own-price and cross-price elasticity of antibiotic demand in layer and broiler production systems.

These and other studies on feed demand have undertaken general feed analysis, Therefore policies formulated do not wholly address certain issues that are prevalent in decion making by different genders. As a result there is a need to extend the research in production inputs to include feed as this will go a long way to inform policy development with the aim of supporting livestock feed manufacture and utilization. The present study examined the demand for poultry feed among smallholder farmers in Kenya by undertaking a study disaggregated by gender.

The rest of the paper is structured as follows: The following section presents literature on demand for livestock feed in developing countries, followed by study areas, sampling, data and description of variables in section 3. Section 4 presents the econometric framework and estimation strategies, followed by results and discussions in section 5. The last section summarizes and concludes, highlighting key findings and policy implications for the feed subsector in Kenya.

2. Literature review: Demand of livestock feed in developing countries

The demand for feed in developing countries has not received much attention with certain sectors receiving almost no attention. Of the several studies undertaken to analyze demand for livestock inputs none has exclusively focused on feed but cover the wide are of production inputs. Kavoi *et al* (2009) analyzed the determinants of the production structure and derived demand for factor inputs in smallholder dairying in Kenya. The study used a restricted translog cost function and found out that dairy production experiences scale diseconomies. Mbugua (2014) analyzed demand for antibiotics in poultry production in Kiambu County, Kenya. The study used a normalized restricted trans-log profit function to estimate own-price and cross-price elasticity of antibiotic demand in layer and broiler production systems. The study found out that-the own

price elasticity of demand for antibiotics was -1.68 for broiler and -1.24 for layers. As observed from the above there is a need to extend the research in production inputs to include feed as this will go a long way to inform policy development with the aim of supporting livestock feed manufacture and utilization.

3. Methods

3.1 Data and data source

The study utilized cross sectional data collected from a random sample of 378 farmer households residing in Kisii county, Kirinyaga county and Nakuru county, in July 2015. The data were collected through face to face interviews using a structured questionnaire; administered by enumerators trained by ICIPE. The survey questionnaires for farmers captured important variables including the socio-economic and demographic attributes of farmer households, the types and quantities of feed used poultry farming, the quantity of purchased used; the quantity of feed mixed on the farm; the source of feed and prices paid for the purchased feed.

3.2. Model Specification

The present study adopts the translog cost function approach to farm level demand for feed for poultry in Kenya. The translog cost function is flexible and is able to use more than one factor. In addition the specification is a second degree flexible function in prices and fixed inputs. Its estimation imposes no restriction; it integrates the input demand functions with the output supply function and uses input prices rather than input quantities. It therefore does not involve the problem of aggregation which is associated with input quantities (Chaudhary *et al.,* 1998). It has both linear and quadratic terms with the ability of using more than two factor inputs (Christensen *et al.,* 1973). Differentiating the translog function with respect to input or output price (or what is known as the Hotelling's lemma), gives the cost share equation for that specific input or output.

The cost shares are the basic forms used to compute price elasticities of inputs and output (Christensen *et al.,* 1973). However, although these less restrictive functional forms are more desirable, they often require more information and thus may come at the expense of parameter estimation (Tocco *et al.,* 2013).

Following Binswanger (1974) the translog total feed cost function for poultry production in Kenya can be specified in equation (1):

$$(1)\ \ln C^{*} = \varphi_0 + \ln \varphi_q Q + \sum_{i=1}^{3} \varphi_i \ln P_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \varphi_{ij} \ln P_i \ln P_i + \sum_{i=1}^{3} \varphi_{iq} \ln P_i \ln Q \text{; i=(1,2 ,3)}$$

where C^{*} is the total cost of feed used in production for the enterprise derived as total costs of the three variable feed inputs (Vegetables, Grains and Purchased mixed feed), Q is the output (number of poultry units), P_i is the money price per kilogram of feed type and φ_0 represents parameters to be estimated. The function can be estimated directly or in its first derivatives which by Shepherd's lemma are the factor share functions (Binswanger, 1974). The share equations for Vegetables, Grains and Purchased Mixed feed are specified as follows:

$$(2)\ \frac{\partial \ln C^{*}}{\partial P_i} = S_i = \frac{P_i X_i}{C^{*}} = \alpha_i + \sum_j \varphi_{ij} \ln P_j + \gamma_{iy} \ln Q \text{ , (i=1,2, 3,)}$$

Where, X_i is the quantity of feed i (Vegetables, Grains and Purchased mixed feed), S_i is the expenditure share for input i. The parameters and symbols are as identified earlier. The farm-level feed demand model can be specified as:

$$(3)\ S_i = \alpha_i + \sum_{j=1} \varphi_{ij} \ln P_j + \sum_{f=1} \beta_i \ln W_f + \gamma_{iy} \ln Q + \varepsilon_i$$

where i indexes the three feed types used in poultry production, f indexes quasi-fixed factors (W); These including age to control for the effect of farming experience on input demand; is distance in kilometers (KM) to nearest trading center to control for effect of market access on input demand; education to control for the effect of access to information on input demand; marital status to control for the effect of access to labor on input demand; employment to control for the effect of access to extra sources of income on input demand; production system to control for the effect of capital outlay on input demand; and bird type to control for the effect of bird type on input demand.

For statistical specification, additive errors with zero expectations and finite variance are assumed for each of the four demand equations of the model. The covariance of the errors of any two of the equations for the same farmer may not be zero, but the covariance of the errors of any two equations corresponding to different farms are assumed to be identically zero. Under these assumptions an asymptotically efficient method of estimation (Zeller, 1962) is used to estimate jointly the system of demand equations (2 and 3) by application of the seemingly unrelated regression (SURE) method. The estimator is an MLE. Symmetry constraints $\left(\varphi_{ij} = \varphi_{ji}\right)$ and adding up restrictions were imposed on the equations. The adding up restriction was

imposed by excluding one equation, in this case the share for vegetables. In addition, the estimated parameters (φ_{ij}) which have little economic meaning of their own were used to derive the elasticity of factor demand (Biswanger,1974; Berndt and Wood, 1984).

(4) $\eta_{ij} = \frac{\varphi_{ij}}{S_i} + S_j$ for all i, j; i ± j

(5) $\eta_{ii} = \frac{\varphi_{ij}}{S_i} + S_i - 1$ for all i

4. Results and Discussion

This section presents both the descriptive statistics of some of the socio-economic and demographic characteristics of the farmers, the quantities and prices of the various types of feed used, expenditure on feed and the results from the econometric estimations.

4.1 Socio-demographic characteristics of the sampled farm households

Table 1 presents the main socio-economic characteristics of poultry farmers. These include age of the farmer, participation in nonfarm sector, marital status of the head of household, size of the household, distance to the nearest feed trader and income. The summary statistics show that an average head of poultry farmer household was about 52 years old with female headed households having a higher average age of 55 years. The mean number of persons in a household was about 4 members for the male headed household but 3 members for a female headed household. The results further show that about 62% of the poultry farmer household surveyed engage in off farm income generating activities with only 38% of the households headed by female engaging in off

farm income generating activities. The results further show that poultry production is dominated by free range farming system (as reported by 53% of the poultry farmers surveyed) with female headed households reporting a higher percentage of 58%. Local birds were the major bird type kept; about 91% of the male headed household reported that they reared local poultry whereas 81% of the female headed households reported that they reared local poultry. The average number of poultry birds reared was 32 poultry birds for both male and female headed households.

Table 1: Characteristics of poultry farmers

	All households (n=386)	**Male headed (n=334)**	**Female headed (n=52)**	**T-statistic**
Characteristic	**Mean**	**Mean**	**Mean**	
Age of the Household head (Years)	52.05 (12.86)	51.58 (12.88)	55.10 (12.37)	0.0666
Education level of the Household head	9.30 (4.75)	9.19 (4.69)	9.96 (5.13)	0.2779
Marital status of the Household head (1=married, 0=otherwise)	0.81 (0.39)	0.92 (0.28)	0.19 (0.40)	0.0000
Engagement in business (1=Yes, 0=No)	0.62 (0.49)	0.65 (0.48)	0.38 (0.49)	0.0002
Distance to a feed trader (KM)	3.74 (11.01)	3.68 (11.7)	4.08 (4.76)	0.8094
Household size	3.77 (1.88)	3.91 (1.80)	2.87 (2.11)	0.0002
Income (Kshs)	60760.99 (148421.10)	55523 (136786.00)	95240 (208738.00)	0.0733
Main Production system (1=Free range, 0=Otherwise)	0.53 (0.50)	0.53 (0.50)	0.58 (0.50)	0.5304
Bird type (1=local, 0=otherwise)	0.88 (0.32)	0.90 (0.31)	0.81 (0.40)	0.0677
Number of poultry units	32.68 (17.85)	32.72 (18.33)	32.19 (14.44)	0.8574

NB: ***Numbers in brackets represent the standard deviation***

4.2 Quantity of feed demanded, feed prices and expenditure on feed

Table 2 reports the average quantity of feed demanded by poultry farmers categorized by feed type. Purchased mixed feed for adult birds was the most highly demanded feed at with an average of 284 kilograms, followed distantly by growers mash at 165 kilograms and Chick and duck mash at 110 kilograms. Female headed households had the highest demand for purchased mixed feed for adult birds at 530 kilograms, while male headed households purchased a higher quantity of growers mash at 167 kilograms Female headed households demanded a lower quantity of own feed than male headed households at 35 kilograms.

Table 2: Average quantity of feed demanded per month by poultry farmers

	Pooled (n=386)	**Male headed (n=334)**	**Female headed (n=52)**	**T-statistic**
Grains	55. (55.50)	56.24 (56.58)	50.15 (45.87)	0.6786
Vegetables	48.37 (50.13)	45.14 (39.20)	72.79 (99.29)	0.0521
Purchased mixed feed (Adult Birds)	283.92 (1,040.19)	238.54 (917.13)	530.46 (1559.19)	0.1183
Growers Mash	165.72 (527.86)	167.49 (543.33)	142.5 (273.86)	0.9118
Chick and Duck Mash	110.33 (320.39)	109.51 (340.65)	115.90 (119.69)	0.9535
Own made	46.24 (55.67)	47.71 (58.78)	35.68 (22.34)	0.5052

Note: **Numbers in brackets represent the standard deviation**

Table 3 reports the average prices paid by poultry farmers in the three counties by feed type per kilogram. Own made feed is the most expensive feed at an average price of Kshs.87.11. Purchased Mixed feeds such as Chick mash and Growers mash cost Kshs 46.84 Kshs 41.49

respectively. Vegetables were the cheapest feed type fed to poultry at an average of Kshs 28.00 which did not differ by a big margin between the male and female headed households. Grains cost an average of Kshs 38.42. Female headed households bought vegetables, grains and made own feed at a higher cost than male headed households while male headed households bought mixed feed for adult birds, growers mash and chick mash at a higher cost than female headed households.

Table 3: Prices at which farmers buy feeds by feed type and county by county

Feed type	All households (N=386)	Male headed Households (n=334)	Female headed Households (n=52)	T-statistic
Unit price of Vegetables	28.00 (10.77)	27.72 (10.60)	29.77 (11.76)	0.2013
Unit price of Grain	38.42 (3.90)	38.40 (3.75)	38.61 (4.77)	0.7136
Unit price of Purchased feed (Adult birds)	43.04 (10.38)	43.09 (10.45)	42.67 (10.03)	0.7830
Unit price of Growers mash	41.49 (8.19)	41.78 (8.02)	39.63 (9.06)	0.0786
Unit price of Chick mash	46.84 (9.15)	47.13 (9.17)	44.95 (8.92)	0.1092
Unit price of own made feed	87.11 (75.12)	86.04 (73.53)	93.95 (85.98)	0.4819

Note The figures in brackets represent standard deviations. Unit prices are in Kshs

Table 4 reports the average expenditure on feed by poultry farmers categorized by feed type and county. Mixed feed had the highest expenditure at Kshs 13869.00, followed distantly by grains at Kshs. 2115.00 then vegetables at Kshs. 1248.00. Kirinyaga had the highest expenditure on purchased mixed feed at Kshs. 26, 150.00 while farmers in Kisii and Nakuru spent less on mixed feed at Kshs.17, 233.00 and Kshs. 11038.00 respectively (Table 4). Male headed households spent more on grains than female headed households. Although there no is a statistical

significant on the mean total expenditures by male and female headed, households female headed households spent more on vegetables and mixed feed compared to the male headed households.

Table 4: Expenditure of feed

Feed type	Pooled	**Male headed (n=334)**	**Female headed (n=52)**	**T-statistic**
Grains	2114.79 (2101.79)	2146.31 (2162.34)	1833.00 (1474.29)	0.5734
Vegetables	1247.83 (1224.96)	1211.42 (1176.26)	1523.57 (1570.92)	0.3724
Mixed feed	13868.91 (56234.02)	12316.48 (54108.28)	23840.30 (68107.56)	0.1696

4.3 Econometric findings and implications

4.3.1 Estimated total cost function poultry feed

Table 5 presents the maximum likelihood estimates for the total poultry feed cost function. According to the results unit value of grains was significant ($p<0.01$) for the sample and only significant ($p<0.01$) for the male-headed households. The unit value of vegetables had a statistically significant ($p<0.05$) influence on the poultry total feed costs for the whole sample and also for the male-headed households. This can be attributed to the fact that total feed costs have a direct relationship with the price. In this study increase in the prices of grains and vegetables increases the total feed costs. The unit value of mixed feed squared for male headed households had a statistically significant influence on total poultry feed cost ($p<0.05$). In addition, the number of poultry units owned has a statistically significant ($p<0.1$) influence of total feed costs for the total sample and for the male-headed households. These results indicate that prices of the feed type given to the poultry influences the total feed costs either positively or negatively. Additionally because feeds constitute the largest proportion of costs involved in

poultry production (Okello *et al*., 2010), their prices and the number of birds reared influence the quantity of feed of each feed type purchased. From the survey data, the vegetables share of the cost was very small (0.077) compared to the rest of the feed types (grains and purchased mixed feed) shares. This can be attributed to availability of the poultry feed types and also that poultry do not feed exclusively on vegetables but have to be supplemented with either grains or purchased mixed feed or both.

Table 5: Maximum likelihood for the total poultry feed cost function[1]

Variable	Coefficient		
	Pooled (n=386)	Male Headed households (n=334)	Female headed Households (n=52)
Ln of unit value of grains	0.735***	1.017***	-0.422
	(2.77)	(3.46)	(-0.76)
Ln of unit value of vegetables	0.516**	0.514**	0.637
	(2.39)	(2.18)	(1.25)
Ln of unit value of mixed feed	-0.252	-0.531	0.785
	(-0.77)	(-1.50)	(1.03)
Ln of number poultry units	-0.840	-0.919	-0.795
	(-1.02)	(-1.01)	(-0.38)
Ln of unit value of grains squared	0.0354	0.0818	-0.0308
	(0.64)	(1.36)	(-0.27)
Ln of unit value of vegetables squared	0.0231	0.0241	0.0472
	(0.53)	(0.51)	(0.45)
Ln of unit value of mixed feed squared	0.0564	0.113*	-0.0220
	(1.00)	(1.82)	(-0.20)
Ln of number of poultry units squared	0.0712*	0.0794*	0.0690
	(1.92)	(1.89)	(0.83)
Ln of unit value of grains* Ln of unit value of vegetables	-0.00105	0.00351	-0.0192
	(-0.03)	(0.09)	(-0.26)
Ln of unit value of grains* Ln of unit value of mixed feed	-0.0344	-0.0853	0.0500
	(-0.68)	(-1.52)	(0.52)
Ln of unit value of grains* Ln of number of poultry units	-0.000474	-0.000133	-0.0569
	(-0.01)	(-0.00)	(-0.37)
Ln of unit value of vegetables* Ln of unit value of mixed feed	-0.0220	-0.0276	-0.0280
	(-0.86)	(-0.99)	(-0.43)
Ln of unit value of vegetables* Ln of number of poultry units	0.00881	0.0100	0.000822
	(0.24)	(0.25)	(0.01)
Ln of unit value of mixed feed *Ln of number of poultry units	-0.0553	-0.0624	-0.0903
	(-1.15)	(-1.21)	(-0.72)
Nakuru	-0.0346	0.0500	-0.000637
	(-0.21)	(0.26)	(-0.00)
Kisii	-0.104	-0.0386	-0.161
	(-0.65)	(-0.22)	(-0.45)
Constant	6.637	6.380	10.35
	(1.59)	(1.36)	(1.07)

t statistics in parentheses

[1] Due to space limitations Interaction terms with other socio-economic variables are not reported

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

4.3.2 Estimated Share demand functions for poultry feed

Examining the responsiveness of farmers to prices of inputs is important for understanding the structure of their production, and thus essential for formulation of a variety of micro policy actions for increased agricultural productivity in farm households. Table 6 below represent maximum likelihoods for grain, mixed feed and vegetable demand functions. In the grain demand function, education level ($p<0.1$) and employment status had a statistically significant influence on the grain demand ($p<0.1$ and $p<0.01$ respectively). In the mixed feed demand function, employment and distance to a feed trader had a statistically significant influence on the mixed feed demand ($p<0.01$ and $p<0.1$ respectively). In the vegetable demand function, age and bird type had a statistically significant influence on the vegetable demand ($p<0.05$ and $p<0.01$). Important also to note, the type of bird kept, if local, have a negative influence on the demand for mixed feed and vegetable while it has a positive influence on the grain demand.

Table 6a: Estimated Grain Share Functions for poultry feed demand

Variables	Grain demand		
	Pooled (n=386)	**Male headed households (n=334)**	**Female Headed households (n=52)**
Ln of unit value of grains	0.0354	0.0818	-0.0308
	(0.64)	(1.36)	(-0.27)
Ln of unit value of vegetables	-0.00105	0.00351	-0.0192
	(-0.03)	(0.09)	(-0.26)
Ln of unit value of mixed feed	-0.0344	-0.0853	0.0500
	(-0.68)	(-1.52)	(0.52)
Ln of number of poultry units	0.0247	0.00951	0.116
	(0.71)	(0.26)	(1.26)
Ln Income	-0.103***	-0.108***	-0.0764
	(-3.05)	(-2.97)	(-0.93)
Age	0.00128	0.00145	0.00188
	(0.89)	(0.93)	(0.57)
Education level	-0.00133	0.00159	-0.0160*
	(-0.37)	(0.41)	(-1.94)
Marital status	0.0699	-0.00540	0.0326
	(1.57)	(-0.08)	(0.32)
Employment status	-0.0000851	0.0444	-0.234***
	(-0.00)	(1.12)	(-2.87)
Distance to the feed trader (KM)	-0.000719	-0.000574	-0.0126
	(-0.47)	(-0.37)	(-1.30)
Production system	0.000929	-0.00536	0.0161
	(0.03)	(-0.15)	(0.17)
Bird type	0.166***	0.144**	0.146
	(2.63)	(2.06)	(1.13)
Nakuru	-0.0617	-0.108*	0.141
	(-1.16)	(-1.82)	(1.32)
Kisii	-0.0372	-0.0582	-0.0240
	(-0.72)	(-1.04)	(-0.19)
Inverse Mills ratio	0.0746***	0.0662***	0.129***
	(5.15)	(4.25)	(2.90)
Constant	0.735***	1.017***	-0.422
	(2.77)	(3.46)	(-0.76)

Table 6b: Estimated Vegetable Share Functions for poultry feed demand

	Vegetable demand		
Variables	**Pooled (n=386)**	**Male headed households (n=334)**	**Female Headed households (n=52)**
Ln of unit value of grains	-0.00105	0.00351	-0.0192
	(-0.03)	(0.09)	(-0.26)
Ln of unit value of vegetables	0.0231	0.0241	0.0472
	(0.53)	(0.51)	(0.45)
Ln of unit value of mixed feed	-0.00279	-0.0186	0.0974
	(-0.07)	(-0.40)	(1.06)
Ln of number of poultry units	0.00881	0.0100	0.000822
	(0.24)	(0.25)	(0.01)
Ln Income	-0.0134	-0.0185	0.0274
	(-0.82)	(-1.04)	(0.56)
Age	-0.00302*	-0.00272	-0.00976**
	(-1.82)	(-1.47)	(-2.51)
Education level	0.000769	0.000676	0.00609
	(0.19)	(0.15)	(0.67)
Marital status	0.0221	-0.0145	0.0972
	(0.43)	(-0.19)	(0.88)
Employment status	0.00876	0.00247	0.0552
	(0.21)	(0.05)	(0.62)
Distance to the feed trader (KM)	0.00341	0.00405*	-0.00354
	(1.48)	(1.70)	(-0.32)
Production system	0.0315	0.0518	-0.0608
	(0.79)	(1.21)	(-0.58)
Bird type	-0.208***	-0.141*	-0.483***
	(-2.97)	(-1.78)	(-3.55)
Nakuru	-0.0617	-0.180	0.110
	(-1.16)	(-1.82)	(1.32)
Kisii	-0.032	-0.082	-0.040
	(-0.72)	(-1.04)	(-0.19)
Inverse Mills ratio	0.076***	0.062***	0.19***
	(5.15)	(4.25)	(2.90)
Constant	0.516**	0.514**	0.637
	(2.39)	(2.18)	(1.25)

Table 6c: Estimated mixed feed Share Functions for poultry feed demand

Variables	Mixed feed demand		
	Pooled (n=386)	**Male headed households (n=334)**	**Female Headed households (n=52)**
Ln of unit value of grains	-0.0344	-0.0853	0.0500
	(-0.68)	(-1.52)	(0.52)
Ln of unit value of vegetables	-0.00279	-0.0186	0.0974
	(-0.07)	(-0.40)	(1.06)
Ln of unit value of mixed feed	0.0564	0.113*	-0.0220
	(1.00)	(1.82)	(-0.20)
Ln of number of poultry units	0.00154	0.0174	-0.0747
	(0.04)	(0.43)	(-0.71)
Ln Income	0.117***	0.127***	0.0490
	(3.14)	(3.18)	(0.53)
Age	0.000432	-0.000186	0.00294
	(0.27)	(-0.11)	(0.79)
Education level	-0.00165	-0.00477	0.0120
	(-0.42)	(-1.12)	(1.32)
Marital Status	-0.0987**	-0.0298	-0.101
	(-2.01)	(-0.42)	(-0.87)
Employment status	0.00223	-0.0482	0.244***
	(0.06)	(-1.11)	(2.76)
Distance to the feed trader (KM)	0.000416	0.0000343	0.0190*
	(0.25)	(0.02)	(1.76)
Production system	-0.0325	-0.0293	-0.0196
	(-0.85)	(-0.73)	(-0.18)
Bird type	-0.161**	-0.139*	-0.143
	(-2.34)	(-1.82)	(-1.00)
Nakuru	0.0919	0.154**	-0.203*
	(1.57)	(2.38)	(-1.68)
Kisii	0.0917	0.121**	0.000451
	(1.61)	(1.98)	(0.00)
Inverse Mills Ratio	-0.0975***	-0.0922***	-0.184***
	(-7.15)	(-6.40)	(-4.25)
Constant	-0.252	-0.531	0.785
	(-0.77)	(-1.50)	(1.03)

4.3.3 Elasticity of demand of poultry feed types

This study derived the own-price and cross-price elasticities for the three feed types used in poultry production by evaluating equation (4 and 5) using estimated coefficients from Table 5

and the associated expenditure shares (Table 6a, 6b and 6c). The elasticity estimates are reported in Table 7. The results show that the own price elasticities of demand for all the feed types are negative and less than unit in absolute value for the sample of farmers surveyed which suggests an inelastic response to the feed utilized but elastic for grains for female headed households.. These results conform to economic theory of demand (Kumar et al., 2010; Varian 1992). Vegetables have the highest own price elasticity of demand of 0.6241 in absolute terms, followed closely by grains (0.6203) and mixed feeds. This probably reflects greater use of own vegetables and supplied grains as feed rather than purchased mixed feed from the market.

Own price elasticities for the grain are inelastic for male headed households but elastic for female headed households. In addition the results indicate that male headed households use vegetables and mixed feed as compliments to grains but female headed households use vegetables as substitutes to grains and compliments to mixed feed. The vegetables own-price elasticities are inelastic for male and female headed households. Male headed households use grains and mixed feed as compliments to vegetables but female headed households use grains as substitutes to vegetables and compliments to mixed feed. This can be attributed to the fact that female headed household's major concern is food provision and thus reduce grain for feeding poultry by a bigger margin when prices for the grains increase. More so, in order to maximize usage of available feeding components and still meet the food demand of the households female headed households substitute grains with vegetables.

In relation to mixed feed own-price elasticities are inelastic for both male and female headed households but female headed households almost double the male headed elasticities in absolute terms. The male headed households use vegetables and grain as compliments to mixed feed but

female headed households have elastic elasticities and use vegetables and grains as compliments to mixed feed.

Table 7: Price and income elasticities of demand

	Pooled	**Male headed households**	**Female headed households**
Grain demand			
Ln Grain Price	**-0.6203**** **(0.2565)**	**-0.4124** **(0.2648)**	**-1.0476** **(0.7362)**
Ln Vegetable Price	0.2013 (0.4543)	0.2716 (0.4948)	-0.1069 (1.0170)
Ln Mixed feed price	0.1656** (0.0726)	0.1026 (0.0820)	0.2180* (0.1249)
Income	-0.0997 (0.1617)	-0.1849 (0.1643)	0.6060 (0.6028)
Vegetable demand	**Pooled**	**Male**	**Female**
Ln Grain Price	0.0724 (0.1634)	0.0934 (0.1698)	-0.0515 (0.4896)
Ln Vegetable Price	**-0.6241** **(0.5620)**	**-0.6129** **(0.6038)**	**-0.2865** **(1.4251)**
Ln Mixed feed price	0.0733 (0.0603)	0.0508 (0.0669)	0.2000* (0.1188)
Income	0.0366 (0.4658)	0.0510 (0.5110)	-0.0626 (1.1355)
Mixed feed demand	**Pooled**	**Male**	**Female**
Ln Grain Price	0.5373** (0.2356)	0.3104 (0.2481)	1.0971* (0.6286)
Ln Vegetable Price	0.6612 (0.5442)	0.4480 (0.5894)	2.0919* (1.2417)
Ln Mixed feed price	**-0.2218***** **(0.0806)**	**-0.1490** **(0.0906)**	**-0.2574*** **(0.1431)**
Income	-0.6951*** (0.550)	-0.6612* (0.0596)	-0.8679* (0.1358)

Standard errors in parentheses
$^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.01$

5 Conclusions and policy implications

The main purpose of this study was to examine demand of poultry feed in Kenya. The study estimated structural models for a system of demand equations, and cost function. In addition, the

feed demand elasticities were computed. The results from the analysis show that feeds are generally price inelastic and price elasticities tend to decrease with rising expenditure level. For instance average own-price elasticities of grains, vegetables and mixed feed were -0.6203, -0.6241 and -0.2218 respectively which is in line with theory that own price elasticity must be negative (Kumar et al., 2010; Varian 1992). However own price elasticity of vegetables is not significant while the own price elasticity of grains is significant at 5% and mixed feed is significant at 1%. This shows that a one percent increase in the price of mixed feed would result in a 0.22 percent decrease in the demand for mixed feed, holding all other factors constant.

Cross price elasticities for all the feeds are positive indicating that they are compliments. Income elasticity for grain and vegetable are not statistically significant while income elasticity for mixed feed is statistically significant ($p<0.1$). Income elasticity with respect to the demand of mixed feed is 0.6951. This indicates that 1% increase in income decreases the demand for mixed feed by 0.6951%.

Therefore from the foregoing results it is highly recommended that farmers especially female headed households be trained on how to make own feed for feeding their birds as this will not only reduce the cost of feed but will also create job opportunities and therefore increase incomes for the farmer and others in the rural areas. In addition policy makers should develop policies that aim at reducing the prices of manufactured feed through the adoption of alternative ingredients such as insect as a source of protein in feed manufacture. Strategies to promote poultry feed consumption should be targeted towards female headed households and female farmers as they are in most instances the owners of poultry and their caretakers.

Acknowledgement

The authors would like to thank International Development Research Centre (IDRC) and the Australian Government for funding the INSFEED project, farmers for their time and information on production inputs, enumerators for taking their time and assist in collecting data and all who participated in this study in any way.

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APPENDIX 1

Map of study areas