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## **Determinants of Food Security in Kenya, a Gender Perspective**

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### **Abstract**

The paper contributes to an understanding of the determinants of food security with a bias on the link between gender of household head and food security using detailed farm household and plot level survey data from 30 divisions in rural Kenya. Both parametric and non-parametric econometric techniques are used to ensure robustness of the results from the econometric analyses. Since the assumption of pooled regression is rejected, we run separate food security regressions at plot level both for Male Headed Households (MHHs) and Female Headed Households (FHHs). Both descriptive and econometrics results shows that FHHs in general are more likely to be food insecure compared to their male counterparts. The analysis further reveals that Female Headed Households' food security increases with quality of extension workers; land quality, farm size while distance to the market reduces the probability of food security. For the quality of extension staff, policy makers should focus on improving the skill of extension staff for efficient and effective dissemination of technologies and other important information that has impact on food security. Since area expansion is infeasible due to land scarcity in Kenya, policy makers focusing on land augmenting practices can help farm households to escape food insecurity.

**Keywords:** food security, gender, parametric and non-parametric methods, Kenya

**JEL code:** O13, Q18

## 1. Introduction

Gender inequalities and lack of attention to gender in agricultural development contribute to lower productivity, and higher levels of poverty as well as under-nutrition (World Bank, FAO and IFAD, 2009; FAO 2011). The 2012 World Development report dedicated to *Gender Equality and Development* warns that the failure to recognize the roles, differences and inequities between men and women poses a serious threat to the effectiveness of the agricultural development (World Bank 2012).

In many countries in Africa, as elsewhere, there has been a significant increase in the percentage of female-headed households (FHH) in recent years. Although African women are disproportionately responsible for providing food to their families both in female-and male-headed households, they have less access to, and control of, agricultural assets and inputs than men. In addition to discrimination in gender difference in observable characteristics, there might be other discrimination which include in terms of accessing different services such as extension and education and unobservable gender difference in characteristics including ability and motivation. They also face more socio-cultural-political barriers compared to their male counterparts. Women carry most of the burden for housework and childcare. This has greater implications on technology adoption, food security and access to markets. Increasing women's access to land, livestock, education, financial services, extension, technology and rural employment would boost their productivity and generate gains in agricultural output, food security, economic growth and social welfare (FAO, 2011).

Although there is a considerable literature on the relationship between gender and agricultural productivity and technology adoption in Sub-Saharan Africa, gender gaps in food security has received far less rigorous empirical attention.<sup>1</sup> In this paper we study the food security of male-and female- headed households using rich household- and plot- level survey data generated by the Kenya Agricultural Research Institute (KARI) in Partnership with the International Maize and Wheat Improvement Center (CIMMYT). More specifically, we aim to answer the following questions: Are female-headed households more likely to be food insecure compared to male-headed households? We use a combination of parametric and non-parametric methods to answer this question and check results robustness.

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<sup>1</sup> For comprehensive econometric evidence review on gender differences in agricultural productivity and technology adoption in the developing world see Peterman et al. (2011; 2010).

The paper contributes to the literature in several directions. First, we consider the household perception of food security measure, which provide a full assessment of the food security situation throughout the year considering own assessment of vulnerability and sustainability dimensions. Based on all food sources (own production+ food purchase + safety nets and welfare programs + ‘hidden harvest’ from communal resources, etc.), the respondents assessed the food security status of their households over the last twelve months in one of the following four categories- food shortage through the year (chronic or severe food insecurity), occasional food shortage (Transitory food insecurity), no food shortage but no surplus (break-even), and food surplus.<sup>2</sup> Although both subjective and objective (consumption-converted into calories or expenditure data) indicators of food security have potential advantages and disadvantages, the use of subjective indicators may help avoid shortcomings associated with using objective indicators of welfare which suffer from recall and under reporting errors. Mallick and Rafi (2010), among others, argue that consumption has large seasonal volatility and most studies use single round of survey, thus consumption data may systematically under- or over- report the true food security. Second, unlike earlier studies (e.g., Mallick and Rafi, 2010) that assumed pooled regression<sup>3</sup> where a gender binary indicator is used to assess the effect of gender on food security, we use exogenous switching regression approach, which allows for differential impacts of covariates on MHHs and FHHs food security regressions. In our sample, the chow test rejects [ $Chi2(31)=108.25***$ ] the assumption of homogeneous impacts implicit in the econometric approaches used in other studies. Third, earlier studies did not compare and analyze MHHs and FHHs who are similar in terms of the distribution of observed gender characteristics. As a result, they might have compared households in the region of no common support, possibly leading to biased conclusions concerning gender impact on food security. We adopt covariate matching methods (Abadie and Imbens, 2004) to balance the covariates among MHHs and FHHs and then, evaluate the average causal effects (differences in average gender food security gaps) of the treatment where the treatment is gender variable. To our knowledge, we are the first to apply such estimators in the context of gender impact on food security. Finally, we use plot

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<sup>2</sup> This question developed following Mallick and Rafi (2010).

<sup>3</sup> This assumption implies that the same set of covariates have the same impact on the probability of MHHs and FHHs food security status (i.e., common slope coefficient for both group). This implies that a binary gender variable has only an intercept shift effect, which is always the same irrespective of the values taken by other covariates that determine food security. However, MHHs and FHHs have different composition of personal characteristics and resource quality which will have different significant implications for food security.

level data which makes it possible to control for plot characteristics which have a direct impact on crop production which subsequently impacts food security and household income.

The next section presents a survey of selected literature on food security. In section 3 we discuss the estimation issues and techniques such as parametric and non-parametric methods. Section 4 contains the data, description of the variables and the descriptive statistics. The empirical results and discussions are found in section 5. Then section 6 concludes the paper with discussions on policy implications.

## **2. A survey of selected literature**

Food security is a broad concept that includes issues related to the nature, quality, food access and security of the food supply (Iram and Butt 2004). The 1996 World Food Summit in Rome defined that “food security exist when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” ( FAO 1996). Hence, there is no single way of measuring food security. Food (in)security has a temporal dimension. It is defined as transitory when a person suffers from a temporary decline in food consumption and as chronic when a person is continuously unable to acquire sufficient food (Chung et al., 1997). During transitory food insecurity a household adopt several strategies but poor households might deplete their productive assets which may lead to chronic food insecurity.

Pinstrup-Andersen (2009) proposes that conditional on making assumptions on income share of household expenditure, and expenditure on other goods and services; and the household behaviors, then the total household income and food prices could be used to estimate the household food security. He further points out that consumption based estimates is an outcome of access to food, household food acquisition and allocation behavior. A food consumption method does not provide a full assessment of the food security because they fail to take into account the vulnerability and sustainability elements of food security.

There is growing literature on food security in developing countries. Most previous studies concentrate on objective food security measures at the household level. These measures look at the consumption (converted into calories) or expenditure data. Mallick and Rafi (2010), among others, argue that consumption has large seasonal volatility and most of these studies use single round of survey, thus consumption data may systematically under or over report the true food security.

Different pillars of food security have been assessed in the literature. For instance, in rural Pakistan, Khan and Gill (2009) analyzed the determinants of three components of food

security i.e. food availability, accessibility and absorption. Food availability is achieved when sufficient quantities of food are available to all individuals. Khan and Gill explain that access to food is attained when household members have enough resources to acquire food. Food absorption/utilization has health dimension and requires a sufficient energy from diet and access to clean water and sanitation. They find that food availability requires the increased production of crops and livestock products. In food accessibility component they found that electrification and adult literacy positively contribute to food accessibility while marginalization of land contributes negatively to food accessibility. For food absorption, they found that child immunization, female literacy, safe drinking water and number of hospitals increase food security.

It has generally been argued that female-headed households are more vulnerable to food insecurity and non-income aspects of poverty. For example, cultural restrictions on women's ability to participate fully in food production activities in some of the poorest areas of South Asia have left them particularly vulnerable in times of economic crisis (Kabeer 1990). McLanahan (1985) finds that children in the female-headed households have a lower rate of socio-economic attainment than children in the male-headed households. If female-headed households utilize all available resources including engaging school going children to income generating activities to survive, then they end up with low education level attainment, thus the probability of transmitting poverty and food insecurity to the next generation is higher. Kennedy and Peter (1992) found that the proportion of income controlled by women has a positive influence on household caloric intake.

At the household level, Feleke et al. (2005) and Kidane et al. (2005) probed the household food security in rural households of Ethiopia. The studies link food security and technology adoption (adoption of high yield varieties of maize and fertilizer application). They concluded that technology adoption do increase household food security. Other factors analyzed include farm size, livestock ownership, education of head of household, household size and per-capita production of the household. With the exception of household size all the other factors increase food security.

A hypothesis that is often raised in the literature is that wealth, assets ownership (e.g. land, livestock) and income is a good predictor of food security (e.g. Iram and Butt 2004; Feleke et al., 2005; Kidane et al., 2005; Babatunde et al., 2008). A household with resources is expected to withstand shocks in production or prices that create food shortages. Unexpected, in Pakistan, Iram and Butt (2004) who measured food security as per capita calories, found that mother education reduce likelihood of food security. Babatunde et al.

(2008) conducted a gender-based analysis of vulnerability to food insecurity in Nigeria. They found that female headed households were more vulnerable to food insecurity than male headed households. They also found that increase in farm size and crop output reduces vulnerability to food insecurity in MHHs. Mallick and Rafi (2010) found no significance differences in the food security between MHHs and FHHs among the indigenous ethnic groups in Bangladesh. Their finding is in contrast to the conventional view that FHHs are vulnerable.

In the literature, studies have also focused on the levels and causes of the food insecurity problems. In general, food insecurity is linked to high food prices, poverty and low agricultural productivity (Nyangweso et al., 2007; Misselhorn, 2005; GoK 2008; Dávila 2010; Lewin 2011). Dávila found that higher prices for maize affected Mexican household living standard and food security both in urban and rural areas, with the poorest net buyers of maize were most affected. In Malawi, Lewin shows that a 25 percent increase in the price of maize flour would increase the likelihood of food insecurity in Northern Malawi by 12 percent, while a similar increase in fertilizer prices would increase food insecurity by 30 percent in the central region. Using dietary diversity among household in a poor Vihiga district in Kenya, Nyangweso et al. found that household income, number of adults, ethnicity, savings behavior and nutritional awareness are critical when addressing the question of food security from the demand side.

Different interventions have been shown to improve food security situation. For instance, participation in drylands interventions (e.g. Makueni district Agricultural Project, Kenya) such as irrigation have been shown by Lemba (2009) to have significant impacts on household food security, which was attributable to improved access to resources (mainly for production). Similar results were found for irrigation schemes in Malawi (Lewin 2011). In Nepal, Tiwari *et al.* (2010) assessed the effects of Maize varietal intervention to improve productivity and food security. They found that food availability increased as a result of the improved varietal intervention with greater relative benefits to poor farmers compared to rich farmers. Nyangito et al. (2004) identified the economic and trade policy reforms introduced in Kenya. They found that Market access for food imports has improved since the reforms, but the capacity to import food has declined, making the country more food insecure.

Other factors hypothesized in the literature to negatively influence food security include: family size and dependency ratio. The effect of education is mixed.

### **3. Econometric estimation methodology and strategy**

To overcome the econometric challenges discussed above and check result robustness we use a combination of parametric and non-parametric methods.

#### **(a) Parametric methods**

The choice of parametric methods partly depends on the nature of the outcome variable, data type, and the objectives to be achieved. We use ordered and binary probit models to estimate gender gaps in food security. Order probit regression is used because the response on food security is ordered in nature. However, because some of the categories have few observations relative to others, we estimate binary probit model to check results robustness. In doing this, the four categories are combined into two: food secure (combining break-even and food surplus) and insecure (combining chronic and transitory food insecurity). As discussed above, we run separate food security regressions both for MHHs and FHHs since the assumption of pooled regression is rejected. Some regressors such as improved seed, fertilizer, and manure adoption, access to credit and participation in land rental market and membership in farmers' association can be endogenous variables. Although covariates that explain these variables are included in the regression models, we run the models with and without these variables to check consistency of the results.

The gender food security gaps are computed as the difference in mean predicted probability of food security obtained from the estimation of separate regression equations. The predicted values are computed at mean of the covariates.

#### **(b) Non-parametric methods**

The empirical distributions of individual characteristics for FHHs and MHHs might be different (gender difference in support). There could be combinations of individual characteristics for which it is possible to find MHHs, but not FHHs, and the vice versa. With such combinations of characteristics one cannot compare food security across genders. The parametric approach may fail to recognize these differences by estimating food security equations for all FHHs and all MHHs without restricting the comparison in the region of common support. Rubin and Thomas (2000) noted that impact estimates using parametric approaches based on full (unmatched) samples are generally more biased than those based on matched samples, as comparison and prediction can be made based on regions of no common support where there are no similar treatment and control groups.

Matching methods have been widely used in the literature on evaluation in looking at the impact of a treatment on an outcome variable. However, recently it is used outside of the



realm of impact evaluation. For instance, Nopo (2008) and Frolich (2007) used matching procedure in the gender wage gap analysis where gender is used as a treatment variable.

We use the nearest-neighbor matching (NNM) technique proposed by Abadie et al., (2004) to estimate the average treatment effect on the treated (ATT). This matching method create comparison group on the basis of observable characteristics. This is called matching on covariates. The treatment variable is gender and the outcome variable is binary household food security.<sup>4</sup>

#### **4. Data and Description of Variables**

We use detailed primary household and plot survey data from 589 farm households and 2,779 plots (defined on the basis of land use), in 88villages in 5 districts of maize-legume systems Kenya. The survey was conducted in January to April 2011.

In the first stage in the sampling procedure, five districts from two regions of Kenya selected based on their maize-legume production potential: Bungoma and Siaya districts from western region and Embu, Meru South, and Imenti South districts from eastern region. Each of the two zones was assigned equal number of sample households. The households within a zone were distributed within the two respective districts according to district household size (proportionate sampling). Multi stage sampling was employed to select lower levels sampling clusters: divisions, locations, sub-locations and villages. In total, 30 divisions were selected- 17 from western Kenya and 13 from Eastern Kenya. Efforts were made to ensure representation of the sample depending on the population of the study areas. Proportionate random sampling was designed where the total number of households in each of the division was compiled. Out of the list, the villages to be surveyed were randomly picked from the list prepared. The number of villages surveyed in each division was proportional to the total number of households in each of the division. Furthermore, a list of households was made from each of the selected village and surveyed households were randomly picked. Thereafter the numbers of the households surveyed in each selected village were randomly picked. The number of households surveyed in each village was proportional to the number of households in that village.

The survey covered detailed household, plot, and village information. Trained enumerators collected a wide range of information on the households' production activities, plot-specific characteristics, demographic and infrastructure information for each household

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<sup>4</sup> We use `nnmatch` in stata 11 to estimate the average treatment effect (Abadie et al. 2004).

and village. The enumerators also collected a number of other plot attributes: Soil fertility, where farmers ranked their plots as poor, medium or good (A dummy variable was set equal to 1 for the selected rank and zero for the others.); Soil depth, where farmers ranked their plots as deep, medium deep or shallow (A dummy variable was set equal to 1 for the selected rank and zero for the others.); Plot size in acres; Distance of the plot from the household dwelling, in minutes of walking. Other information collected at the plot level was tenure status of plots, crop production estimates, and inputs associated with each type of agricultural activity.

Key socioeconomic elements collected about the household include age, gender, education level, family size, asset ownerships, membership in farmers' organizations, consumption expenditures, farmers' expectations on social safety nets (social insurance) when crop production fails (1= yes, and zero otherwise), number of traders the respondent knows in their vicinity, production constraints (such as crop pests, diseases, and input availability), and how much land a household owns.

Information was also collected on governance indicators, such as government effectiveness<sup>5</sup> and political connections. Empirical evidence supports the positive role of government effectiveness and political connections on economic growth and a firm's investment performance (Dixit 2004; Faccio 2006). Recent literature in new institutional economics suggests that formal institutions provided for by the state are not the only ones that matter for economic development (Dixit 2004). Informal institutions, such as political connections—which are a more fundamental aspect of networking—play a significantly positive role in the performance of firms or individuals by facilitating investment and credit. In our case, connections with local administrators and agricultural officials may lead to better access to inputs and credit supplied by the public institutions.

We measured government effectiveness using respondents' perception of the competence of extension workers. Farmers were asked to score their confidence (on a scale of 1 to 7, where 7 signifies high confidence) in the ability of extension workers to accomplish their jobs. This variable is converted into a dummy variable, where 1 indicates confidence in the qualification of extension workers (slightly agree to strongly agree) and zero shows lack of confidence (strongly disagree to indifferent). For the political connections variable, we set a dummy variable equal to 1 if the respondent has relatives or friends in a leadership position in and outside the village, and zero otherwise.

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<sup>5</sup> Government effectiveness measures the quality of civil services and quality and quantity of public infrastructure, as well as organizational structure of public offices (Kaufmann et al. 2007).

The household survey also includes individual rainfall shock variables derived from respondents' subjective rainfall satisfaction, in terms of timelines, amount, and distribution. The individual rainfall index was constructed to measure the farm-specific experience related to rainfall in the preceding three seasons, based on such questions as to whether rainfall came and stopped on time, whether there was enough rain at the beginning and during the growing season, and whether it rained at harvest time.<sup>6</sup> Responses to each of the questions (yes or no) were coded as favorable or unfavorable rainfall outcomes and averaged over the number of questions asked (five questions), so that the best outcome would be equal to 1 and the worst to zero.<sup>7</sup>

#### **(a) Descriptive statistics**

MHHs and FHHs are 81 and 19 per cent of all the households in the sample, respectively. About 82 and 18 per cent of the total plots (2779 plots) are operated by MHHs and FHHs, respectively.

Definitions of variables used in the analysis and summary statistics and statistical significance tests on equality of means for continuous variables and equality of proportions for binary variables for male- and female-headed households are presented in table 1.

The results in table 1 show that, about 11 per cent of the FHHs suffer from chronic food insecurity compared to 5 percent of the MHHs. Similarly, about 47 and 41 per cent of the FHHs and MHHs suffer from transitory food insecurity, respectively. The difference in chronic food insecurity between MHHs and FHHs is statistically significant. On the other hand, about 39(14) per cent of the MHHs fall under the categories of break-even (food surplus) compared to 32(10) per cent of the FHHs. About 53 per cent of the MHHs are food secure (break even and food surplus are combined into food secure) compared to 42 per cent of the FHHs. This difference is statistically significant. The distribution of food expenditures (own production plus purchase) by gender confirm this results (see figure 1). The Kolmogorov-Smirnov test for equality of distribution functions shows that the distance between the functions is statistically significant ( $D = 0.184^{***}$ ). Food expenditures constitute about 63 per cent of the total annual household expenditures.

FHHs, on average, have less farm size and education level compared to their male counterparts. The differences in farm size and education level are statistically significant. As

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<sup>6</sup> We followed Quisumbing (2003) to construct this index.

<sup>7</sup> Actual rainfall data is, of course, preferable, but getting reliable village-level data in most developing countries, including Kenya, is difficult.

shows in Table 2, the probability of being food secure and food expenditures increase with farm size and level of education. Government policies that focus on increasing productivity per unit area using modern inputs and investment in education may increase the likelihood of FHHs escape food insecurity.

Apart from absolute farm size difference, FHHs have less quality land. About 13 per cent of the cultivated area owned by FHHs fall under poor soil fertility category compared to 8 per cent owned by MHHs. Forty-nine per cent of the total cultivated land owned by MHHs is good to medium fertile land compared to 39 per cent of FHHs owned land. This difference may be associated due to low use of land quality enhancing inputs (fertilizer and manure) and plots managed by FHHs are relative far from their dwellings. In addition, FHHs rent out more land than MHHs. This may likely affect quality of land in case tenants do not properly manage rented in lands.

MHHs and FHHs are also differing in their livestock and bicycle ownership which is an important means of transport both for produce and human being. Livestock and bicycle ownerships are statistically different between MHHs and FHHs, where MHHs own more livestock and bicycle.

The unconditional summary statistics and tests in the tables above in general suggest that FHHs are more food insecure as well as they lack important resources that have repercussion on their welfare including food security. However, because food security is the outcome of interaction of several factors we need to add careful multivariate analysis to study the causal effect of gender of household head on food security.

## **5. Empirical results and discussion**

This section presents results from parametric and non-parametric methods. We first briefly discuss the determinants of food security before we discuss the causal effect of gender on food security.

### **(a) Determinants of food security**

In most cases the qualitative results of binary probit and ordered probit model are the same. The results of the determinants of food security with and without including the potential endogenous variables are presented in Tables 3-7. We reported both the marginal effects and robust standard errors. In the probit model, the dependent variable is a binary food security status equals one if the household is food secure and zero otherwise, while in the order probit

model, it is a categorical variable (1=chronic food insecurity, 2= Transitory food insecurity, 3=Break-even, and 4=food surplus). Because our interest is on the average gender food security difference, we briefly discuss the determinants of food security.

As indicated in Tables 3-7, the marginal effects of covariates are different both for MHHs and FHHs. This supports the chow test result and thus running a separate food security regression for both groups. In addition, some of the covariates that explain the food security probability of MHHs do not explain the FHHs food security status and the vice-versa.

The probit model results show that both household and plot level factors conditioned the probability of MHHs and FHHs food security. The probability of FHHs food security is influenced by quality of extension staff, expectations on social safety nets (social insurance), access to grain traders, physical capital (farm size and farm equipment ownership), membership in farmers' association, land quality, access to main market, human capital (dependency ratio and age), plot distance to dwelling, and geographic location (district dummies). Similarly, human capital (age, dependency ratio, available adult labor), physical capital (farm size, farm equipment and bicycle ownerships), distance to main market, input use (manure and chemical fertilizer), natural capital (soil fertility), and location variables (district dummies) are all significantly associated with the probability of MHHs food security.

The likelihood of FHHs food security significantly increases with quality of extension staff. The coefficient of this variable is insignificant in the MHHs binary probit equation but significant in the ordered probit model (OPM). Number of traders that FHHs know in and outside the village is positively influence the likelihood of FHHs food security. Traders can improve market access through regular supply of inputs and outputs as well as through provision of credit (interlinked contract). However, this variable has no significant effect on the probability of food security of MHHs. Distance to main market significantly decreases the probability of food security both for FHHs and MHHs.

Surprisingly improved seeds, chemical fertilizer and manure adoption did not explain FHHs food security status, while manure and chemical fertilizer have a positive and significant impact on the probability of MHHs food security status.

In the OPM, rainfall satisfaction index and political connections variables significantly influence households' food security status.

### **(b) Impact of gender of household head on food security**

The parametric results on the average causal effect of gender on food security are presented in Table 8. Because the food security difference results obtained from models with and without

including the potential endogenous variables are not significant, we did not report average effect results from the models with endogenous variables. The results are available on request.

As evident in Table 8, FHHs in general are more likely to be food insecure than their male counterparts. The mean predicted probability of food security obtained from the probit model estimation shows that, FHHs are 13 per cent less likely to be food secure than MHHs. The OPM results also confirm this result. FHHs face 3 and 12 percent higher probability of chronic and transitory food insecurity, respectively, than MHHs. For break-even and food surplus categories households, the MHHs have about 5 and 9 per cent higher probability of food security than FHHs.<sup>8</sup>

Although the results are qualitative similar using non-parametric methods, the average probability of gender food security gap (ATT) is reduced substantially. The matching variables used are the same as the variables used in the parametric approach (See Table 4). The covariate matching results indicate that, MHHs have 1.3 and 2.8 per cent higher probability of food security than FHHs with and without including potential endogenous variables, respectively. This finding suggests that a lot of gender food security difference is in fact captured by the observed variables. The remaining food security gap (the part that cannot be explained by observed characteristics) may be attributed to less observable factors, such as discrimination and unobservable gender difference in characteristics such as ability and motivation. In addition, noneconomic institutions, such as culture and religion, influence food security. Kabeer (1990) noted that socio-cultural reasons to be an important factor for the female-headed households' higher food insecurity.

## **6. Conclusions and policy implications**

Using recent household and plot survey data from maize-legume systems in rural Kenya, we test if female-headed households (FFHs) are more likely to be food insecure compared to male-headed households (MHHs). In that respect, after controlling for other several relevant covariates and using balanced covariates, female-headed households in general are less food secure compared to their male counterparts.

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<sup>8</sup> Although regression estimates are not reported, qualitatively similar results obtained from the estimation of the annual per capita household food expenditure. MHHs have higher and significant food expenditures (Ksh 16101) than FHHs.

All the farmers in our dataset reported their perceived food security. This gives us an opportunity to explore the subjective measure of food security which provides a full assessment of the food security situation throughout the year where households consider their vulnerability. Since the assumption of pooled regression is rejected, we run separate food security regressions at plot level both for MHHs and FHHs households.

It deserves to be noted that the descriptive statistics and tests in general suggest that FHHs are more food insecure as well as they lack important resources that have repercussion on their welfare including food security. About 11 per cent of the FHHs suffer from chronic food insecurity compared to 5 percent of the MHHs. The difference in chronic food insecurity between MHHs and FHHs is statistically significant. With statistically significant difference, about 53 per cent of the MHHs are food secure (break even and food surplus are combined into food secure) compared to 42 per cent of the FHHs. Tabulation of food security and food expenditures by land and education level shows that the probability of being food secure and food expenditures increase with farm size and level of education.

The econometric results confirm the descriptive results that FHHs in general are more likely to be food insecure than their male counterparts. The mean predicted probability of food security difference obtained from the probit model estimation shows that, FHHs are 13 per cent less likely to be food secure than MHHs. similar results are shown for the ordered probit model. Similar results were obtained using the order probit model where FHHs suffer more from chronic (3%) and transitory (12%) food insecurity. For the break-even and food surplus category, the MHHs have about 5% and 9% higher probability of food security than the FHHs. However, using covariate matching the gender food security gaps between female- and male-headed households is reduced to 1.3-2.8 percent, indicating that the remaining food security gap (the part that cannot be explained by gender differences in observed characteristics) may be attributed to less observable factors, such as discrimination and unobservable gender differences in characteristics including ability and motivation.

The determinants of food security from parametric results suggest that FHHs food security increases with quality of extension workers; land quality, farm size while distance to the market reduces the probability of food security. These results have important policy implications. For the quality of extension staff, policy makers should focus on improving the skill of extension staff for efficient and effective dissemination of technologies and other important information that has impact on food security. Since area expansion is infeasible due to land scarcity in Kenya, policy makers focusing on land augmenting practices can help farm households to escape food insecurity. Although little can be done with respect to distance to

markets, policy interventions could improve road quality and traffic through improving existing road networks and maintaining existing ones. Such investment is likely to have a positive impact on market integration, productivity and food security.

Finally, future analysis using repeated observations (or panel data) may be needed to examine the relationship between gender and food security in order to control for unobserved specific heterogeneity and to see if the MHHs-FHHs food security gap persists over time.

## References

- Abadie, A., D. Drukker, J. L. Herr, and G. W. Imbens, 2004. Implementing matching estimators for average treatment effects in Stata. *Stata Journal* 4(3): 290-311.
- Babatunde R.O., O.A. Omotesho, E.O. Olorunsanya and G.M. Owotoki, 2008. Determinants of Vulnerability to food insecurity: A gender-based analysis of farming households in Nigeria. *Indian Journal of Agricultural Economics* 63:1, 116-125
- Chung, K., Haddad, L., Ramakrishna, J., & Riely, F. 1997. Identifying the food insecure: The application of mixed-method approach in India. Washington DC: International Food Policy Research Institute.
- Dávila O. G. 2010 Food security and poverty in Mexico: the impact of higher global food prices. *Food Security* 2:383–393.
- Dixit, A.K. 2004. Lawlessness and Economics: Alternative Mode of Governance. Princeton, NJ, USA: Princeton University Press.
- Feleke, S, T., R, L. Kilmer, and C, H. Gladwin. 2005. Determinants of food security in Southern Ethiopia at household level. *Agricultural Economics Journal*. 33, 351-363
- Faccio, M. 2006. Politically Connected Firms. *American Economic Review* 96: 369–86.
- FAO (Food and Agricultural Organization). 1996. Rome Declaration on World Food Security and World Food. FAO, Rome, Italy.
- FAO 2002. Food insecurity: When people must live with hunger and fear starvation. The state of food insecurity in the world 2002. FAO. Rome, Italy.
- FAO 2011. The State of Food and Agriculture 2010-2011. Women in Agriculture, Closing the gender gap for development. FAO Rome.  
<http://www.fao.org/docrep/013/i2050e/i2050e00.htm> (assessed 31st January 2012)
- Frolich, M. 2007. Propensity score matching without conditional independence assumption—with an application to the gender wage gap in the United Kingdom. *Econometrics Journal* 10: 359–407
- GoK (Government of Kenya) .2008. First Medium Term Plan (2008-2012). Kenya Vision 2030: A Globally Competitive and Prosperous Kenya, Nairobi.
- Heckman, J. & Vytlacil, E. (2007). Econometric evaluation of social programs, part 2, Using the marginal treatment effect to organize alternative economic estimators to evaluate social programs and to forecast their effects in new environments. In Handbook of econometrics, vol. 6, ed. J. Heckman and E. Leamer, Amsterdam, Elsevier Science.
- Iram U., and M. S. Butt. 2004. Determinants of household food security: An empirical analysis for Pakistan. *International Journal of Social Economics*, 31(8): 753 – 766
- Kabeer, N. 1990. Women, household food security and coping strategies. Nutrition Policy Discussion Paper (UN/ACC) No. 6, Geneva, Switzerland.
- Kennedy E., and Peters P. 1992 “Household Food Security and Child Nutrition: The Interaction of Income and Gender of Household Head” *World Development*, 20( 8) 1077-1085.



- KFSN (Kenya Food Security Network) 2011 KENYA Dekadal Food Security Monitoring August 22, 2011  
[www.fews.net/docs/publications/ke\\_dekadal\\_report\\_2011\\_08\\_22\\_final.pdf](http://www.fews.net/docs/publications/ke_dekadal_report_2011_08_22_final.pdf)
- Khan, R. E. A. and A. R. Gill. 2009. Determinants of Food Security in Rural Areas of Pakistan. Munich Personal RePEc Archive (MPRA)
- Kidane, H., Z. G. Alemu, and G. Kundhlande. 2005. Causes of household food security in Koredegaga peasant association, Oromiya Zone, Ethiopia. *Agrekon* 44(4):543-560
- Kaufmann, D., A. Kraay, and M. Mastruzzi. 2007. Governance Matters VI—Aggregate and Individual Governance Indicators: 1996–2006. Policy Research Working Paper, No. 4280. Washington, DC: World Bank.
- Lemba, J.K. 2009. Intervention model for sustainable household food security in the drylands of Kenya: Case study of Makueni district. PhD thesis, Ghent University
- Lewin P.A. 2011. Three Essays on Food Security, Food Assistance, and Migration. PhD thesis, Oregon State University
- Mallick D., and M. Rafi. 2010. Are female-headed households more food insecure? Evidence from Bangladesh. *World development* 38 (4): 593-605
- McLanahan, S. 1985. “Family structure and the reproduction of poverty.” *American Journal of Sociology*, 990(4), 873–901.
- Misselhorn A.A. 2005 . What drives food insecurity in southern Africa? a meta-analysis of household economy studies. *Global Environmental Change*, 15: 33–43
- (MoA) Ministry of agriculture, 2008. Food security in Kenya. Republic of Kenya
- NOPO, H. 2008. “Matching as a Tool to decompose Wage Gaps”. *The review of economics and statistics*, 90 (2): 290-299.
- Nyangito H. O., J. Nzuma, H. Ommeh, and M. Mbithi. 2004. Impact of Agricultural Trade and Related Policy Reforms on Food Security in Kenya. The Kenya Institute For Public Research and Analysis (KIPPRA), Nairobi KIPPRA Discussion Paper No. 3.
- Nyangweso P.M., M.O Odhiambo, P. Odunga, M.K. Korir, M.J. Kipsat and A.K. Serem. 2007. Household food security in Vihiga district, Kenya: determinants of dietary and diversity. African Crop Science conference proceedings vol 8 pp 1383-1389
- Peterman A, A.R., Quisumbing, J. Behrman and E.Nkonya. 2011, Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda. *Journal of Development Studies*, 47(10): 1482-1509.
- Peterman, A., J. Behrman and A.R. Quisumbing. 2010. A Review of Empirical Evidence on Gender Differences in non-land Agricultural Inputs, Technology, and Services in Developing Countries. *Food Policy*: 1-48.
- Pinstrup-Andersen P. 2009 “Food security: definition and measurement”. *Food security*, 1. 5-7
- Ouma, J., F. Murithi, W. Mwangi, H. Verkuijl, M. Gethi, and H. D. Groote. 2002. Adoption of Maize Seed and Fertilizer Technologies in Embu District, Kenya, Mexico, D.F.: CIMMYT (International Maize and Wheat Improvement Center).
- Quisumbing, A.R. 2003. Food Aid and Child Nutrition in Rural Ethiopia. *World Development* 31(7): 1309–1324.
- Rubin D.B. and N, Thomas. 2000. Combining propensity score matching with additional adjustments for prognostic covariates. *Journal of the American Statistical Association* 95 (450), 573–585.
- Smale, M., and T. Jayne. 2003. Maize in Eastern and Southern Africa: Seeds of Success in Retrospect, EPTD Discussion Paper No. 97
- Tiwari T. P. , G. Ortiz-Ferrara ,D. B. Gurung , R. Dhakal, R. B. Katuwal ,B.B. Hamal , N.Gadal and D. S. Virk. 2010. Rapid gains in food security from new maize varieties

for complex hillside environments through farmer participation. *Food Security*, 2:317–325

World Bank, FAO and IFAD, 2009. *Gender in Agriculture Sourcebook*. The World Bank, Washington D.C.

World Bank 2012 World Development report: *Gender Equality and Development*. . The World Bank, Washington D.C.

## Appendix 1

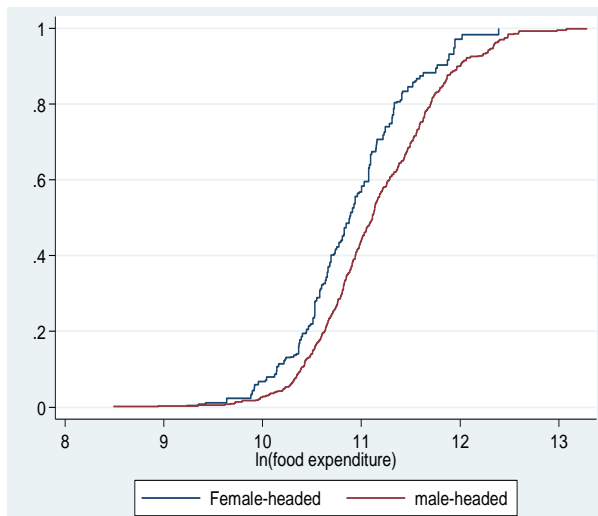


Figure 1. Food expenditures distribution by gender

Table 1: Descriptive statistics and description of variables

		Male farmers		Female farmers		mean diff
		Mean	SD	Mean	SD	
<b>Dependent Variables</b>						
Food security	Household food security status (1=food secure; 0= food insecure)	0.53	0.5	0.42	0.5	0.11
Chronic food insecurity	Household suffer from chronic food security(1=yes; 0=no)	0.01	0.1	0.02	0.13	0.01
Transitory food insecurity	Household suffer from transitory food security(1=yes; 0=no)	0.04	0.21	0.09	0.28	0.04
Break-even food security	Household has break-even security(1=yes; 0=no)	0.41	0.49	0.47	0.5	0.06
Food surplus	Household has food surplus(1=yes; 0=no)	0.39	0.49	0.32	0.47	0.06
<b>Independent variables</b>						
Varadopt	Adoption of any improved seed varieties	0.46	0.5	0.43	0.5	0.03
Fertdummy	Chemical fertilizers adoption (1=yes; 0=no)	0.52	0.5	0.48	0.5	0.05
Plotdist	Plot distance to dwelling (in walking minutes)	6.91	16.2	8.05	19.33	-1.14
Godfertplt (ref)	Farmers' perception that plot has good fertile soil (1=yes; 0=no)	0.33	0.47	0.25	0.43	0.08
Modfertplt	Farmers' perception that plot has moderately fertile soil (1=yes; 0=no)	0.54	0.5	0.53	0.5	0.01
Porfertplt	Farmers' perception that plot has poor fertile soil (1=yes; 0=no)	0.13	0.34	0.22	0.41	-0.09
Areagodfert	Proportion of cultivated area under good fertile soil	0.2	0.55	0.13	0.29	-0.07***
Areamodfert	Proportion of cultivated area under moderately fertile soil	0.29	0.6	0.26	0.3	-0.03
Areaporfert	Proportion of cultivated area under poor fertile soil	0.08	0.29	0.13	0.3	0.05***
Shwdepplt(ref)	Farmers' perception that plot has shallow deep soil (1=yes; 0=no)	0.15	0.35	0.14	0.35	0.01
Moddepsolplt	Farmers' perception that plot has moderately deep soil (1=yes; 0=no)	0.65	0.48	0.67	0.47	-0.02
Depsolplt	Farmers' perception that plot has deep soil (1=yes; 0=no)	0.21	0.4	0.19	0.4	0.01
Govtfect	Farmers confident in skill of extension agents (1 = yes; 0 = no)	0.7	0.46	0.75	0.43	-0.05
Connection	Household has relative in leadership position (1 = yes; 0 = no)	0.51	0.5	0.4	0.49	0.1
Trader	Number of traders that farmer knows (number)	7	7.57	5.26	4.12	1.74
Govtsup	Household can rely on government during crop failure (1 = yes; 0 = no)	0.57	0.49	0.62	0.49	-0.05
Educ	Education level of household head (years of schooling)	7.99	3.61	4.54	3.96	3.45
Age	Age of household head (years)	47.76	12.25	51.65	11.99	-3.89

Adultlab	Adult family labor available (number)	1.19	0.44	1.1	0.59	0.08
Ownland (ref)	Own plot (1=yes; 0=no)	0.89	0.32	0.87	0.34	0.55
Rentinland	Rented in plot (1=yes; 0=no)	0.1	0.3	0.1	0.3	-0.21
Rentoutland	Rented out plot (1=yes; 0=no)	0.02	0.13	0.03	0.16	-0.15
Farmsize	Total farm size(acre)	0.78	0.88	0.61	0.52	0.17
TLU	Number of livestock (TLU)	2.37	2.68	1.76	1.65	0.61
Assetval	Asset value of major farm equipments ('000 KSh)	2.51	3.88	2.56	5.97	0.05
Ownbicycle	Own bicycle (1=yes; 0=no)	0.63	0.48	0.46	0.5	0.16
Rainfallindex	Rainfall satisfaction index	0.58	0.32	0.56	0.3	0.03
Manuse	Amount of manure use on a plot('000 Kg)	0.71	1.06	0.55	0.84	0.16
Mktdist	Distance to main market (in walking minutes)	78.59	52.58	84.12	58.81	-5.53
Group	Participation in farmers' group or association (1 = yes; 0 = no)	0.74	0.44	0.74	0.44	0
Season	Crop production season (1=long rainy season;0=short rainy season)	0.53	0.5	0.52	0.5	0.02
Bungoma (ref)	Bungoma District (1 = yes; 0 = no)	0.26	0.44	0.16	0.37	
embu	Embu district (1 = yes; 0 = no)	0.17	0.37	0.24	0.43	
imenti south	Imenti south district (1 = yes; 0 = no)	0.17	0.38	0.13	0.34	
meru south	Meru south district (1 = yes; 0 = no)	0.18	0.38	0.13	0.34	
siaya	Siaya district (1 = yes; 0 = no)	0.23	0.42	0.34	0.48	
Number of Plot (household) observations		2274(475)		505(114)		

Table 2: Food security and food expenditures by land category and education level

Quartiles	Land		Education	
	Food security (%)	Annual food expenditure (Ksh)	Food security	Food expenditure (Ksh)
1 (Lowest)	44	59885	50	62710
2(Lowest middle)	47	72946	48	63498
3 (Upper middle)	52	77437	52	79637
4(Highest)	61	87410	54	88951

Table 3: Binary probit results on the determinants of food security status

Variables	With potential endogenous variables						Without potential endogenous variables						
	Male head			Female head			Variables	Male head			Female head		
	dy/dx	SE	P>z	dy/dx	SE	P>z		dy/dx	SE	P>z	dy/dx	SE	P>z
Extskill	0.036	0.027	0.194	0.205	0.060	0.001	Extskill	0.035	0.027	0.203	0.191	0.057	0.001
Govtsup	0.007	0.025	0.772	0.131	0.063	0.036	Govtsup	0.006	0.025	0.795	0.114	0.058	0.049
Trader	0.002	0.001	0.159	0.040	0.006	0.000	Trader	0.002	0.001	0.175	0.039	0.006	0.000
Connection	0.043	0.025	0.085	-0.069	0.059	0.248	Connection	0.044	0.025	0.074	-0.071	0.058	0.222
Age	-0.006	0.001	0.000	0.007	0.003	0.008	Age	-0.006	0.001	0.000	0.008	0.003	0.003
Educ	-0.005	0.004	0.184	0.009	0.009	0.332	Educ	-0.004	0.004	0.230	0.008	0.009	0.364
Depratio	-0.024	0.006	0.000	0.036	0.010	0.000	Depcyratio	-0.024	0.006	0.000	0.037	0.010	0.000
Adultlab	-0.112	0.036	0.002	0.046	0.055	0.409	Adultlab	-0.113	0.036	0.002	0.054	0.054	0.320
TLU	-0.005	0.005	0.365	0.041	0.024	0.092	TLU	-0.001	0.005	0.847	0.028	0.024	0.249
ln(Farmsize)	0.087	0.016	0.000	0.095	0.041	0.021	ln(Farmsize)	0.081	0.015	0.000	0.097	0.038	0.011
Assetval	0.006	0.003	0.040	0.013	0.005	0.006	Assetval	0.006	0.003	0.021	0.014	0.005	0.003
Ownbycle	0.102	0.026	0.000	-0.053	0.063	0.401	Ownbycle	0.097	0.025	0.000	-0.046	0.061	0.454
Mktdist	-0.001	0.000	0.014	-0.002	0.001	0.001	Mktdist	-0.001	0.000	0.007	-0.002	0.001	0.001
Rainfallindex	0.014	0.042	0.739	0.038	0.123	0.758	Rainfallindex	0.021	0.042	0.613	0.032	0.117	0.782
plotdist	0.000	0.001	0.562	-0.001	0.002	0.337	plotdist	0.000	0.001	0.783	-0.002	0.001	0.100
Modfertplt	-0.168	0.026	0.000	-0.153	0.077	0.047	Modfertplt	-0.175	0.026	0.000	-0.120	0.074	0.103
Porfertplt	-0.339	0.036	0.000	-0.299	0.078	0.000	Porfertplt	-0.353	0.035	0.000	-0.291	0.075	0.000
Moddepsolplt	0.054	0.034	0.109	-0.147	0.096	0.125	Moddepsolplt	0.043	0.033	0.191	-0.166	0.095	0.081
Depsolplt	0.025	0.041	0.534	-0.032	0.100	0.748	Depsolplt	0.020	0.040	0.616	-0.062	0.101	0.540
Season	-0.021	0.023	0.356	-0.016	0.052	0.762	Season	-0.013	0.023	0.561	0.007	0.051	0.886
Group	-0.013	0.027	0.636	0.110	0.061	0.070	embu	0.315	0.030	0.000	0.760	0.063	0.000
Manuse	0.026	0.009	0.003	-0.015	0.020	0.452	imenti south	0.453	0.022	0.000	0.663	0.064	0
Rentinland	0.064	0.046	0.163	-0.139	0.076	0.067	meru south	0.382	0.025	0.000	0.682	0.065	0.000
Rentoutland	-0.159	0.090	0.077	-0.214	0.140	0.125	siaya	0.154	0.035	0.000	0.272	0.125	0.030
Fertdummy	0.084	0.025	0.001	0.081	0.062	0.192							
Imseed	-0.027	0.026	0.299	0.096	0.062	0.125							

embu	0.295	0.032	0.000	0.742	0.069	0.000		
imenti south	0.445	0.023	0.000	0.675	0.061	0.000		
meru south	0.367	0.027	0.000	0.687	0.066	0.000		
siaya	0.152	0.036	0.000	0.214	0.130	0.100		
<hr/>								
Model diagnostic								
Wald chi2(30/25)	521.00			202.330			503.530	191.870
Pseudo R2	0.196			0.374			0.188	0.350
Log likelihood	-1247.221			-221.027			-1256.813	-227.051
Predicted probabilities	0.592			0.374			0.592	0.344
Observations	2274			505			2274	505
<hr/>								

Table 4: Ordered probit results on the determinants of MHHs food security status(with potential endogenous variables)

Variables	Coefficients			Marginal effects											
	coeff	SE	P-value	Chronic food insecurity			Transitory food insecurity			Break-even			Food surplus		
				dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value
Extskill	0.124	0.055	0.024	-0.009	0.004	0.033	-0.040	0.018	0.024	0.023	0.011	0.031	0.026	0.011	0.020
Govtsup	-0.033	0.053	0.530	0.002	0.004	0.528	0.011	0.017	0.530	-0.006	0.009	0.527	-0.007	0.011	0.532
trader	0.002	0.003	0.500	0.000	0.000	0.503	-0.001	0.001	0.500	0.000	0.001	0.501	0.000	0.001	0.500
Connection	0.173	0.051	0.001	-0.012	0.004	0.001	-0.055	0.017	0.001	0.030	0.009	0.001	0.037	0.011	0.001
Age	-0.005	0.002	0.027	0.000	0.000	0.033	0.002	0.001	0.027	-0.001	0.000	0.029	-0.001	0.000	0.027
Educ	-0.013	0.008	0.092	0.001	0.001	0.091	0.004	0.002	0.093	-0.002	0.001	0.096	-0.003	0.002	0.091
Depratio	-0.023	0.011	0.037	0.002	0.001	0.038	0.007	0.003	0.038	-0.004	0.002	0.038	-0.005	0.002	0.037
Adultlab	-0.014	0.072	0.849	0.001	0.005	0.849	0.004	0.023	0.849	-0.002	0.013	0.849	-0.003	0.016	0.849
TLU	-0.011	0.010	0.270	0.001	0.001	0.271	0.004	0.003	0.270	-0.002	0.002	0.272	-0.002	0.002	0.269
ln(Farmsize)	0.162	0.030	0.000	-0.011	0.002	0.000	-0.052	0.010	0.000	0.028	0.005	0.000	0.035	0.007	0.000
Assetval	0.018	0.007	0.008	-0.001	0.000	0.008	-0.006	0.002	0.009	0.003	0.001	0.010	0.004	0.001	0.008
Ownbycle	0.237	0.054	0.000	-0.018	0.005	0.000	-0.075	0.017	0.000	0.044	0.011	0.000	0.049	0.011	0.000
Mktdist	-0.001	0.000	0.161	0.000	0.000	0.167	0.000	0.000	0.161	0.000	0.000	0.164	0.000	0.000	0.161
Rainfallindex	-0.237	0.091	0.009	0.016	0.006	0.010	0.076	0.029	0.010	-0.041	0.016	0.010	-0.051	0.020	0.010
plotdist	-0.003	0.002	0.198	0.000	0.000	0.208	0.001	0.001	0.197	-0.001	0.000	0.201	-0.001	0.000	0.198
Modfertplt	-0.272	0.056	0.000	0.018	0.004	0.000	0.087	0.018	0.000	-0.046	0.010	0.000	-0.060	0.012	0.000
Porfertplt	-0.630	0.085	0.000	0.067	0.013	0.000	0.180	0.021	0.000	-0.143	0.023	0.000	-0.104	0.011	0.000
Moddepsolplt	0.065	0.068	0.336	-0.005	0.005	0.346	-0.021	0.022	0.336	0.011	0.012	0.344	0.014	0.014	0.332
Depsolplt	0.156	0.083	0.059	-0.010	0.005	0.044	-0.050	0.027	0.060	0.025	0.012	0.036	0.035	0.020	0.074
Season	-0.054	0.047	0.248	0.004	0.003	0.250	0.017	0.015	0.248	-0.009	0.008	0.247	-0.012	0.010	0.249
Group	0.076	0.056	0.175	-0.005	0.004	0.194	-0.024	0.018	0.174	0.014	0.010	0.189	0.016	0.012	0.168
Manuse	0.027	0.017	0.116	-0.002	0.001	0.121	-0.009	0.006	0.116	0.005	0.003	0.121	0.006	0.004	0.114
Rentinland	0.323	0.094	0.001	-0.017	0.004	0.000	-0.103	0.030	0.000	0.041	0.008	0.000	0.080	0.026	0.003
Rentoutland	0.071	0.222	0.750	-0.005	0.013	0.733	-0.023	0.072	0.751	0.011	0.033	0.731	0.016	0.052	0.759



Fertdummy	0.216	0.051	0.000	-0.015	0.004	0.000	-0.069	0.016	0.000	0.038	0.009	0.000	0.047	0.011	0.000	
Imseed	-0.033	0.052	0.522	0.002	0.004	0.522	0.011	0.017	0.522	-0.006	0.009	0.523	-0.007	0.011	0.521	
embu	0.560	0.101	0.000	-0.028	0.004	0.000	-0.176	0.030	0.000	0.058	0.006	0.000	0.146	0.030	0.000	
imenti south	0.972	0.092	0.000	-0.042	0.005	0.000	-0.288	0.025	0.000	0.055	0.010	0.000	0.276	0.030	0.000	
meru south	0.766	0.087	0.000	-0.036	0.005	0.000	-0.235	0.025	0.000	0.064	0.007	0.000	0.207	0.027	0.000	
siaya	0.198	0.080	0.013	-0.012	0.005	0.007	-0.064	0.026	0.013	0.031	0.011	0.006	0.046	0.019	0.017	
/cut1	-1.717	0.236														
/cut2	-0.058	0.231														
/cut3	1.265	0.232														
Model diagnostic																
Wald chiw(30)	543.78															
Pseudo R2	0.0937															
Log likelihood	-2434.382															
predicted probabilities				0.03			0.384			0.451			0.134			
Observations	2274			2274			2274			2274			2274			

Table 5: Ordered probit results on the determinants of MHHs food security status(without potential endogenous variables)

Variables	Coefficients			Marginal effects											
	coeff	SE	P-value	Chronic food insecurity			Transitory food insecurity			Break-even			Food surplus		
				dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value
Extskill	0.118	0.054	0.028	-0.009	0.004	0.037	-0.037	0.017	0.027	0.021	0.010	0.035	0.025	0.011	0.024
Govtsup	-0.037	0.052	0.477	0.003	0.004	0.474	0.012	0.017	0.477	-0.006	0.009	0.473	-0.008	0.012	0.479
trader	0.002	0.003	0.435	0.000	0.000	0.439	-0.001	0.001	0.435	0.000	0.001	0.437	0.000	0.001	0.434
Connection	0.188	0.052	0.000	-0.014	0.004	0.001	-0.060	0.016	0.000	0.033	0.009	0.000	0.041	0.011	0.000
Age	-0.005	0.002	0.011	0.000	0.000	0.015	0.002	0.001	0.011	-0.001	0.000	0.012	-0.001	0.000	0.011
Educ	-0.011	0.008	0.163	0.001	0.001	0.160	0.003	0.002	0.165	-0.002	0.001	0.167	-0.002	0.002	0.161
Depratio	-0.023	0.011	0.032	0.002	0.001	0.032	0.007	0.003	0.033	-0.004	0.002	0.033	-0.005	0.002	0.032
Adultlab	-0.032	0.072	0.662	0.002	0.005	0.662	0.010	0.023	0.662	-0.005	0.012	0.662	-0.007	0.016	0.662
TLU	-0.004	0.010	0.681	0.000	0.001	0.680	0.001	0.003	0.681	-0.001	0.002	0.681	-0.001	0.002	0.680
ln(Farmsize)	0.127	0.028	0.000	-0.009	0.002	0.000	-0.041	0.009	0.000	0.022	0.005	0.000	0.028	0.006	0.000
Assetval	0.020	0.007	0.003	-0.001	0.000	0.003	-0.006	0.002	0.004	0.003	0.001	0.005	0.004	0.001	0.003
Ownbycle	0.240	0.053	0.000	-0.018	0.005	0.000	-0.075	0.017	0.000	0.043	0.011	0.000	0.050	0.011	0.000
Mktdist	-0.001	0.000	0.158	0.000	0.000	0.164	0.000	0.000	0.159	0.000	0.000	0.162	0.000	0.000	0.157
Rainfallindex	-0.226	0.090	0.012	0.016	0.007	0.013	0.072	0.029	0.013	-0.039	0.015	0.013	-0.049	0.020	0.013
plotdist	-0.001	0.002	0.743	0.000	0.000	0.744	0.000	0.001	0.742	0.000	0.000	0.743	0.000	0.000	0.742
Modfertplt	-0.283	0.055	0.000	0.020	0.004	0.000	0.090	0.018	0.000	-0.047	0.010	0.000	-0.063	0.012	0.000
Porfertplt	-0.653	0.085	0.000	0.073	0.014	0.000	0.183	0.021	0.000	-0.148	0.023	0.000	-0.108	0.010	0.000
Moddepsolplt	0.032	0.067	0.635	-0.002	0.005	0.637	-0.010	0.021	0.634	0.006	0.012	0.637	0.007	0.015	0.633
Depsolplt	0.133	0.082	0.106	-0.009	0.005	0.085	-0.042	0.026	0.107	0.021	0.012	0.077	0.030	0.020	0.122
Season	-0.034	0.046	0.461	0.002	0.003	0.461	0.011	0.015	0.461	-0.006	0.008	0.460	-0.008	0.010	0.461
embu	0.632	0.096	0.000	-0.032	0.004	0.000	-0.195	0.028	0.000	0.057	0.006	0.000	0.170	0.030	0.000
imenti south	1.006	0.089	0.000	-0.045	0.005	0.000	-0.295	0.023	0.000	0.050	0.010	0.000	0.289	0.029	0.000
meru south	0.819	0.081	0.000	-0.040	0.005	0.000	-0.248	0.023	0.000	0.062	0.008	0.000	0.226	0.025	0.000

siaya	0.215	0.078	0.006	-0.014	0.005	0.003	-0.069	0.025	0.006	0.032	0.011	0.002	0.050	0.019	0.009
/cut1	-1.861	0.232													
/cut2	-0.224	0.227													
/cut3	1.088	0.229													
<hr/>															
Model Diagnostic															
Wald chiw(24)	486.84														
Pseudo R2	0.087														
Log likelihood	-2452.8048														
predicted probabilities				0.032		0.383		0.449						0.136	
Observations	2274			2274		2274		2274						2274	
<hr/>															

Table 6: Ordered probit results on the determinants of FHHs food security status(with potential endogenous variables)

Variables	Coefficients			Marginal effects											
	coeff	SE	P-value	Chronic food insecurity			Transitory food insecurity			Break-even			Food surplus		
				dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value
Extskill	-0.010	0.121	0.934	0.001	0.009	0.934	0.003	0.038	0.934	-0.003	0.037	0.934	-0.001	0.010	0.935
Govtsup	0.534	0.128	0.000	-0.045	0.014	0.001	-0.156	0.037	0.000	0.162	0.038	0.000	0.039	0.012	0.002
trader	0.041	0.013	0.001	-0.003	0.001	0.003	-0.013	0.004	0.002	0.013	0.004	0.003	0.003	0.001	0.001
Connection	-0.248	0.119	0.036	0.019	0.011	0.076	0.076	0.036	0.032	-0.076	0.036	0.033	-0.019	0.011	0.072
Age	0.019	0.006	0.001	-0.001	0.000	0.001	-0.006	0.002	0.001	0.006	0.002	0.001	0.001	0.001	0.004
Educ	0.026	0.017	0.134	-0.002	0.001	0.125	-0.008	0.006	0.143	0.008	0.005	0.137	0.002	0.001	0.150
Depratio	0.037	0.025	0.134	-0.003	0.002	0.120	-0.012	0.008	0.142	0.011	0.008	0.141	0.003	0.002	0.126
Adultlab	-0.024	0.117	0.837	0.002	0.009	0.837	0.008	0.036	0.837	-0.007	0.036	0.837	-0.002	0.009	0.836
TLU	-0.001	0.059	0.980	0.000	0.004	0.980	0.000	0.019	0.980	0.000	0.018	0.980	0.000	0.005	0.980
ln(Farmsize)	0.108	0.093	0.246	-0.008	0.007	0.251	-0.034	0.029	0.248	0.033	0.029	0.251	0.008	0.007	0.238
Assetval	0.047	0.011	0.000	-0.004	0.001	0.000	-0.015	0.004	0.000	0.014	0.004	0.000	0.004	0.001	0.000
Ownbycle	-0.096	0.123	0.435	0.007	0.009	0.446	0.030	0.038	0.434	-0.030	0.038	0.433	-0.008	0.010	0.451
Mktdist	-0.004	0.001	0.000	0.000	0.000	0.003	0.001	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.003
Rainfallindex	0.607	0.235	0.010	-0.046	0.020	0.023	-0.189	0.074	0.010	0.187	0.073	0.010	0.048	0.021	0.021
plotdist	-0.006	0.003	0.039	0.000	0.000	0.070	0.002	0.001	0.037	-0.002	0.001	0.042	0.000	0.000	0.047
Modfertplt	-0.295	0.141	0.036	0.022	0.011	0.048	0.092	0.044	0.039	-0.090	0.042	0.034	-0.024	0.013	0.067
Porfertplt	-0.423	0.195	0.030	0.040	0.023	0.083	0.116	0.047	0.013	-0.129	0.059	0.030	-0.027	0.010	0.008
Moddepsolplt	0.149	0.160	0.350	-0.012	0.013	0.381	-0.045	0.048	0.339	0.046	0.049	0.349	0.011	0.012	0.347
Depsolplt	0.278	0.205	0.174	-0.018	0.011	0.115	-0.091	0.070	0.195	0.084	0.060	0.162	0.026	0.022	0.241
Season	-0.051	0.103	0.621	0.004	0.008	0.622	0.016	0.032	0.622	-0.016	0.032	0.621	-0.004	0.008	0.624
Group	0.147	0.123	0.231	-0.012	0.011	0.274	-0.044	0.036	0.221	0.045	0.037	0.224	0.011	0.010	0.261
Manuse	0.046	0.039	0.237	-0.003	0.003	0.267	-0.014	0.012	0.233	0.014	0.012	0.240	0.004	0.003	0.237
Rentinland	-0.078	0.172	0.652	0.006	0.014	0.663	0.024	0.051	0.646	-0.024	0.053	0.652	-0.006	0.012	0.637

Rentoutland	-0.510	0.298	0.087	0.059	0.049	0.225	0.120	0.045	0.008	-0.153	0.082	0.062	-0.026	0.011	0.021
Fertdummy	0.164	0.127	0.198	-0.012	0.010	0.218	-0.051	0.040	0.197	0.050	0.039	0.199	0.013	0.010	0.210
Imseed	0.029	0.121	0.810	-0.002	0.009	0.809	-0.009	0.038	0.811	0.009	0.037	0.810	0.002	0.010	0.810
embu	1.593	0.284	0.000	-0.078	0.018	0.000	-0.493	0.073	0.000	0.317	0.039	0.000	0.253	0.066	0.000
imenti south	1.716	0.280	0.000	-0.057	0.013	0.000	-0.523	0.061	0.000	0.230	0.046	0.000	0.349	0.088	0.000
meru south	1.540	0.347	0.000	-0.055	0.012	0.000	-0.486	0.087	0.000	0.253	0.038	0.000	0.288	0.100	0.004
siaya	0.272	0.253	0.282	-0.019	0.016	0.252	-0.087	0.083	0.293	0.082	0.076	0.279	0.024	0.023	0.309
/cut1	0.797	0.516	-0.215	1.809											
/cut2	2.875	0.560	1.777	3.973											
/cut3	4.425	0.590	3.269	5.581											
<hr/>															
Model diagnostic															
waldchi2(30)		210.58***													
Pseudo R2		0.1864													
Loglikelihood		-460.955													
predicted probabilities					0.034			0.565			0.365			0.036	
Observations		505			505			505			505			505	
<hr/>															

Table 7: Ordered probit results on the determinants of FHHs food security(without potential endogenous variables)

Variables	Coefficients			Marginal effects											
	coeff	SE	P-value	Chronic food insecurity			Transitory food insecurity			Break-even			Food surplus		
				dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value	dy/dx	SE	P-value
Extskill	-0.007	0.113	0.948	0.001	0.009	0.948	0.002	0.035	0.948	-0.002	0.035	0.948	-0.001	0.009	0.949
Govtsup	0.522	0.123	0.000	-0.045	0.014	0.001	-0.152	0.036	0.000	0.157	0.037	0.000	0.040	0.013	0.001
trader	0.041	0.013	0.002	-0.003	0.001	0.003	-0.013	0.004	0.003	0.013	0.004	0.003	0.003	0.001	0.001
Connection	-0.257	0.119	0.030	0.020	0.011	0.065	0.079	0.035	0.027	-0.078	0.035	0.027	-0.021	0.011	0.062
Age	0.019	0.005	0.001	-0.001	0.000	0.001	-0.006	0.002	0.001	0.006	0.002	0.001	0.002	0.001	0.004
Educ	0.025	0.017	0.159	-0.002	0.001	0.151	-0.008	0.006	0.167	0.007	0.005	0.160	0.002	0.001	0.176
Depratio	0.040	0.026	0.116	-0.003	0.002	0.099	-0.012	0.008	0.126	0.012	0.008	0.125	0.003	0.002	0.105
Adultlab	-0.014	0.114	0.901	0.001	0.009	0.901	0.004	0.035	0.901	-0.004	0.035	0.901	-0.001	0.009	0.901
TLU	-0.002	0.056	0.971	0.000	0.004	0.971	0.001	0.017	0.971	-0.001	0.017	0.971	0.000	0.005	0.971
ln(Farmsize)	0.097	0.086	0.260	-0.007	0.007	0.262	-0.030	0.027	0.264	0.030	0.026	0.263	0.008	0.007	0.263
Assetval	0.046	0.011	0.000	-0.004	0.001	0.000	-0.014	0.004	0.000	0.014	0.004	0.000	0.004	0.001	0.000
Ownbycle	-0.059	0.122	0.629	0.005	0.009	0.632	0.018	0.038	0.629	-0.018	0.037	0.628	-0.005	0.010	0.634
Mktdist	-0.004	0.001	0.000	0.000	0.000	0.004	0.001	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.002
Rainfallindex	0.540	0.229	0.018	-0.042	0.020	0.033	-0.167	0.072	0.020	0.164	0.070	0.020	0.044	0.021	0.033
plotdist	-0.006	0.002	0.013	0.000	0.000	0.029	0.002	0.001	0.013	-0.002	0.001	0.016	0.000	0.000	0.017
Modfertplt	-0.290	0.132	0.028	0.022	0.011	0.044	0.090	0.041	0.028	-0.088	0.039	0.026	-0.024	0.013	0.054
Porfertplt	-0.521	0.186	0.005	0.053	0.025	0.034	0.137	0.040	0.001	-0.157	0.055	0.005	-0.033	0.010	0.001
Moddepsolplt	0.118	0.156	0.449	-0.009	0.013	0.469	-0.036	0.047	0.441	0.036	0.048	0.450	0.009	0.012	0.439
Depsolplt	0.210	0.204	0.304	-0.014	0.012	0.241	-0.068	0.069	0.324	0.063	0.060	0.297	0.019	0.021	0.352
Season	-0.009	0.102	0.926	0.001	0.008	0.926	0.003	0.032	0.926	-0.003	0.031	0.926	-0.001	0.008	0.926
embu	1.685	0.262	0.000	-0.083	0.019	0.000	-0.512	0.064	0.000	0.311	0.039	0.000	0.284	0.065	0.000
imenti south	1.705	0.266	0.000	-0.058	0.013	0.000	-0.519	0.059	0.000	0.225	0.046	0.000	0.352	0.085	0.000
meru south	1.590	0.328	0.000	-0.058	0.012	0.000	-0.496	0.080	0.000	0.244	0.041	0.000	0.310	0.099	0.002

siaya	0.372	0.228	0.104	-0.026	0.015	0.087	-0.119	0.075	0.114	0.110	0.067	0.098	0.035	0.024	0.145
/cut1	0.647	0.521													
/cut2	2.713	0.569													
/cut3	4.240	0.602													
<hr/>															
Model diagnostic															
Wald chiw(24)	197.68***														
Pseudo R2	0.18														
Log likelihood	-464.5527														
predicted probabilities					0.035			0.565			0.362				0.037
Observations	505				505			505			505				505
<hr/>															

Table 8 : The mean predicted probability of food security and/or average treatment effect on the treated by gender

Household type	Binary probit model	Ordered probit model			
	Outcome variable: binary food security	Outcome variable: Food security category			
		Chronic food insecurity	Transitory food insecurity	Break-even	Food surplus
Female-headed	0.44	0.08	0.49	0.35	0.08
Male-headed	0.57	0.05	0.37	0.41	0.17
Difference	0.13 (0.013)***	0.03 (0.004)***	0.12 (0.008)***	-0.05 (0.006)***	-0.09 (0.006)***

Figure in parenthesis are standard errors.