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Gendered food security in rural Malawi: Why is women's food security status lower?

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Abstract

Gendered food security gaps between female- and male-headed households (FHHs and MHHs) can be decomposed into two components: one explained by observable differences in levels of resource use (i.e. the quantity or level effect) and a residual component due to unobserved differences affecting the returns to the resources used (i.e. the efficiency or return effect). Employing an exogenous switching ordered probit regression model, this paper examines the gendered food security gap and its causes in rural Malawi. We conduct a counterfactual analysis and find that food security of FHHs would improve significantly if their current resources yielded the same returns as those of MHHs. The improvement would be higher for *de facto* FHHs than for *de jure* FHHs. With similar returns to resource use, the number of *de jure* FHHs classified as chronic (transitory) food insecure would decline by 2.5(5.1) percentage points and those classified as food breakeven (surplus) increase by 5.6 (2.0) percentage points. However, even if FHHs food security would improve under the similar returns to resource use scenario the gendered food security gap would not be closed because of the quantity or level effect. Returns to resources explain 43% (47%) of the observed gendered chronic (transitory) food insecurity gap and 72% (23%) of the food breakeven (surplus) gap. Further analysis suggests that the intensity of adoption of sustainable agricultural practices has a stronger impact on the food security of *de jure* FHHs than on MHHs and *de facto* FHHs.

Key words: Gender; food security; observed and unobserved inequalities; exogenous switching regression, ordered probit model; Malawi.

Introduction

The economies of most African countries encompass an agricultural sector dominated by smallholder farmers that are only partially integrated into markets. The performance of the agricultural sector directly affects national economic development, food security and poverty alleviation. While the sector employs about 65% of the labor force, it contributes only about 30-40% of the total gross domestic product (World Bank, 2013). A key hindrance to agricultural growth and development are gender inequalities in various dimensions (Mark et al., 2006; World Bank 2013). Both the general literature on gender and development (World Bank 2001) as well as specific works on Africa (World Bank 2000; 2013) have argued that reducing gender inequalities can be a powerful force for growth and poverty reduction in Africa.

Women generally have less access to various resources and services (e.g. land, education, inputs, and training) that are crucial for agricultural productivity (Quisumbing, 1995; Odame et al., 2002; Dolan, 2004; Mark et al., 2006; World Bank, 2001; World Bank, 2013; Kassie et al. 2014). The problem is not only that women are disadvantaged in their access to resources, but also that the returns to their resources are low (World Bank, 2013). In addition to relatively easily observable gender differences, women frequently face less easily observable problems in their day-to-day farming activities, such as less access than men to short-term agricultural credit, to extension services and input markets (Chipande, 1987; Due and Gladwin, 1991; Minot et al., 2000; Gilbert et al., 2002). For instance, our survey results show that female headed households (FHHs) had lower intensity of fertilizer use (69 vs. 87 kg/acre) and extension services/contact per year (36 vs. 42) compared to male headed households (MHHs). This means that FHHs will frequently be less productive in their farming than MHHs (World Bank, 2012; 2013; Meinzen-Dick et al. 2011). Since some of these gender differences are caused by day-to-day inequalities that may be hard to measure, it also means that gender differences in productivity may well remain even when the observable differences in resource access are taken into account. These day-to-day inequalities will also affect any empirical analysis, because the effect of changes in access to one or several of the observed resource indicators will depend on what other inequalities are being observed in the same study. Finally, these inequalities also mean that FHHs and MHHs will have different scope for adopting new technologies, such as sustainable agricultural practices (SAPs), and may also experience different impacts from adoption of these technologies.

This paper investigates whether FHHs in Malawi are more likely to be food insecure compared to MHH, and what the underlying causes of this gap are. This is done through the use of an impact evaluation methodology – exogenous switching regression in a counterfactual manner – using the gender of the household head as exogenous treatment variable. By applying this method and using a rich data set, we disentangle the effects of different types of gender inequalities in food security in more detail than previously done. Specifically, this method decomposes the gender gap in food security into two components: a component explained by observable differences in FHHs and MHHs resource use (i.e. the quantity or level effect)[1], and a residual component due to unobserved differences between households affecting the returns to the resources used (i.e. the efficiency or return effect). The residual component includes potentially unobserved gender inequalities/discrimination such as resource quality differences, social norms, differences in farming experience, and differential access to services and other gendered market failures or institutional constraints that alter the effectiveness of resource use for FHHs and MHHs (World Bank, 2013).

Gendered food security inequalities have attracted numerous empirical studies (e.g., Barros et al., 1997; Buvinić and Rao 1997, Fuwa, 2000; Quisumbing et al., 2001; Iram and Butt, 2004; IRIN, 2006; Babatunde et al., 2008; Mallick and Rafi, 2010; Kassie et al., 2014). These studies have generally, and perhaps unsurprisingly, found that FHHs tend to be more food insecure than MHHs are. However, most of these studies (a notable exception being Kassie et al., 2014) assume that the entire difference between FHHs and MHHs can be captured in a fruitful way merely by using a gender dummy in a pooled regression model. There are, however, important problems with this approach. As noted above, men and women in many agricultural societies face a number of different inequalities in their farming activities. These inequalities will affect production outcomes directly, but may also have indirect effects through other variables. For instance, gender differences in access to credit may affect how readily FHHs and MHHs, respectively, adopt a new farming practice, because the new practice implies a different set of liquidity pressures over the year than the old practice does (Phiri, 1986; Due and Gladwin, 1991). However, gender differences may also affect what the actual productivity difference is between the new and the old practice, because both practices will depend on access to land, training and other factors where FHHs may also be at a disadvantage. A simple gender dummy will capture the difference in eventual outcome, but will do little to explain how this difference is generated by the various underlying differences, which are frequently complicated and may well change over time due to social and economic pressures (Peters, 1997; Doss, 2001). Ideally, an empirical analysis

[11] In this paper we will use “resources use” and “characteristics” interchangeably..

should capture not merely the gender difference in outcomes, but also model and disentangle gender differences in the underlying factors.

Further, previous research on gendered food security mostly did not distinguish FHHs into *de jure* and *de facto* FHHs [2] but, instead, assumed homogeneous FHHs; however, these two types of FHHs may have different food security functions, and aggregating them into a single function risks misestimating the gendered food security gap.

In this paper, we take a different direction from past empirical work in two ways. First, rather than using the traditional gender dummy (sex of the household head) as indicator variable in the regression models, we apply impact evaluation methodologies in the context of gender impact on food security. In particular, exogenous switching regression is used in a counterfactual manner to understand the heterogeneity effect of MHHs and FHHs (*de jure* and *de facto* FHHs) resources on food security by allowing gender variable interaction with other resources of FHHs and MHHs. This methodology allows decomposing the gendered food security gap into the portions caused by observable and unobservable resources/characteristics.

Second, unlike most other papers, we do not base our analysis on objective food security measures. Rather, we focus on farm households' self-reported subjective food security status which can capture the seasonal fluctuation of consumption, households' vulnerability and the multidimensional nature of food security (Mallick and Rafi, 2010; The economist Intelligence Unit, 2012).[3] Consumption data has a large seasonal volatility and most studies use only a single-round survey that frequently focuses on the last month before the survey was run. It is often subject to infrequent purchase problems (food purchase after the interview) and measurement errors because of farmers' recall. Therefore, consumption data may systematically under- or over-report the true food security scenario, depending on the time of year the survey was conducted. Psychologists and more recently economists have made ample use of individual subjective assessments to study well-being, quality of life, job satisfaction, and welfare.[4] A common conclusion from the literature is that subjective-

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[2] In this study, we define households as FHHs if they belong to either of the following categories: *de jure* FHHs (if they are run by single, widowed divorced or separated women) and *de facto* FHHs (where there still is a virtual husband who is not physically present on the farm, because, e.g., he is working elsewhere). This is in line with previous literature in this field (see e.g. Kennedy and Peters, 1992; Peters, 1995, 1997; Dolan, 2004; or Takane, 2008, 2009).

[3] Clark (1997), Kahneman and Krueger (2006), van Praag et al., (2003) discuss about the reliability of subjective measures but in different contexts.

[4] Subjective questions may depend on a number of distorting factors related to individual differences including cognitive ability, personality traits, circumstances, aspirations and comparisons with others. If these factors are important, subjective evaluations may contain a great deal of noise relative to the signal value, and the resulting

wellbeing provides a more inclusive and holistic picture of welfare than traditional objective measures, such as income or consumption (Frey and Stutzer 2002; Kahneman and Krueger 2006; Angner 2010; Stutzer and Frey 2010; van Hoorn et al 2010). Studies have also shown that subjective well-being measures are highly correlated in mostly predictable ways with a variety of demographic, economic and societal-level characteristics (the review article by Stutzer and Frey 2010 provides a useful summary). In the economics literature, Deaton (2010) argues for a wider use of self-reported measures in international monitoring surveys; Ravallion and Lokshin (2002) used subjective economic welfare measures in Russia and Mallick and Rafi, (2010) and Kassie et al., (2014) used subjective measures of food security in Bangladesh and Kenya, respectively. In our case, following Mallick and Rafi (2010), the food security indicator is constructed as follows. Based on all food sources (own production + food purchase + safety nets and welfare programs + 'hidden harvest' from communal resources), the respondents assessed the food security status of their own households. The subjective food security status of the family captured for the preceding 12 months was grouped into the following four categories: food shortage throughout the year (chronic food insecurity), occasional food shortage (transitory food insecurity), no food shortage but also no surplus (food breakeven), and food surplus.

Measuring the gendered food security gap: Exogenous switching regression

The traditional econometric approach assessed the gendered food security gap using pooled regression, a gender dummy variable included in the regression and assumed homogeneous covariates impact on FHHs and MHHs food security status. Using a common slope coefficient for both groups implicitly assumes that there is no interaction between gender and other covariates; indicating that gender has only an intercept effect or parallel shift effect on food security, which is always the same irrespective of the values taken by other covariates that determine food security. Applying a Chow test, the assumption of a homogenous slope effect is rejected [$\chi^2(46) = 152.95^{***}$, p=0.000], giving a strong indication that gender-specific coefficient estimates are indeed important.

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estimations should be interpreted skeptically. However, studies in both psychology and economics have demonstrated that the influence of these factors is limited, and that self-reported data pass a number of validation tests (Budria andTelhado-Pereira, 2009). An additional point (see e.g. Onjala et al., 2014, who study subjective risk perceptions) is that behavior will be determined by subjective perceptions, rather than by objective indicators; thus, studies that purport to explain people's behavior can benefit from using these subjective perceptions.

To investigate gender differences in the food security pattern, we apply exogenous switching regression assuming a gender treatment variable. The model is specified as:

$$\begin{cases} S_{if} = \beta_f X_f + \varepsilon_f \\ S_{im} = \beta_m X_m + \varepsilon_m \end{cases} \quad (2)$$

Here S indicates the ith household's self-reported food security outcome variables such that 1 = Chronic food insecurity (CF), 2 = Transitory food insecurity (TF), 3 = Food breakeven (FB) and 4 = Food surplus (FS); f and m denote FHHs and MHHs, respectively; X is a vector of observable household and plot characteristics affecting food security; and β are the associated returns/prices (parameters)to characteristics, and ε is unobservable influencing food security.

Equation (2) is used to produce a counterfactual food security distribution, and decomposes the gendered food security gap into the portion of the gender gap that is caused by differences in the levels or quantity of observable resources/characteristics (quantity or level effect) between both groups and the portion of the gender gap explained by differences in the returns to these resources /characteristics (the efficiency or return effect). Following Kassie et al. (2014), the gender wage decomposition and the impact evaluation literatures, the expected conditional expectations presented in Table 1 and defined below are computed from equation (2) in the actual and counterfactual scenarios:

$$E(S_m|g = 1) = \beta_m X_m \quad (4a)$$

$$E(S_f|g = 0) = \beta_f X_f \quad (4b)$$

$$E(S_f|g = 1) = \beta_f X_m \quad (4c)$$

$$E(S_m|g = 0) = \beta_m X_f \quad (4d)$$

where g is a gender variable equal to one for MHHs and zero for FHHs, E is expected operator, and where $S =,$ CF, TF, FB and FS as defined above.

Equations 4a and 4b represent the actual expected proportion of food (in)secure FHHs and MHHs actually observed in the data, respectively. Equations 4c and 4d represent the "counterfactual" expected food (in)security status for MHHs and FHHs, respectively. The counterfactual is what the expected food (in)security status of FHHs would have been if the returns to their characteristics had been the same as the current returns to MHHs' observed characteristics, and vice versa.

<Table 1 about here>

Using these conditional expectations, the expected gender food (in) security outcomes due to differences in resources use and returns are derived. The FHHs' expected food (in)security status (Fs_f) due to differences in returns is obtained by subtracting 4d from 4b, that is, the difference of the counterfactual expected food (in)security status of FHHs (4d) and their actual expected food (in)security status (4b),

$$Fs_f = E(S_m|g = 0) - E(S_f|g = 0) = X_f(\beta_m - \beta_f) \quad (5)$$

This is the food security gain that FFHs would experience if they had had the same observed characteristics as they do now, but the same returns to those observed characteristics as MHHs have now. It is the proportion of the food security gap that is not explained by observable gender differences in characteristics. This measures food security variation due to unobserved gender inequalities including unobserved FHHs and MHHs characteristics (e.g. resource quality differences, differences in farming experience, or differential access to services, as discussed earlier). Similarly, the difference between the actual expected food (in)security status of MHHs (4a) and their counterfactual expected food (in)security status (4c) gives their average food (in)security outcomes (Fs_m) defined below:

$$Fs_m = E(S_m|g = 1) - E(S_f|g = 1) = X_m(\beta_m - \beta_f) \quad (6)$$

Again, this is the food security loss/gain that MHHs would experience if they had had the same characteristics as they do now, but had had the same returns to their characteristics as the FHHs have now.

Equations (5) and (6) are equivalent to the average treatment effect on the treated and untreated, respectively, in the impact evaluation literature and the coefficient effects in the wage decomposition literature where MHHs (FHHs) had FHHs' (MHHs') returns to characteristics.

The food security gap due to differences in observable characteristics (LE) is given as the difference between 4a and 4d when MHHs food security function is used and 4b and 4c when the FHHs food security function is used.

$$LE_m = E(S_m|g = 1) - E(S_m|g = 0) = \beta_m(X_m - X_f) \qquad (7a)$$

$$LE_f = E(S_f|g = 1) - E(S_f|g = 0) = \beta_f(X_m - X_f) \qquad (7b)$$

The levels effect (LE) show, respectively, what the food security gap would have been if all households had had the current MHHs returns (or characteristics weighted by the return/price effect, β_m) and the current FHHs returns (or characteristics weighted by, β_f) to the observable characteristics. In wage decomposition terminology, equation 7a and 7b represent the explained part of the gendered food security gap. In this paper we focus on 7a as FHHs are expected to move to MHHs food security function trajectory.

Following the gender wage decomposition literature, the total food security gap (FSG) as contributed by the levels and returns effect is given as follow focusing on MHHs food security function.

$$FSG_m = \beta_m(X_m - X_f) + X_f(\beta_m - \beta_f) \qquad (8)$$

These equations will provide information on the relative importance of observed FHHs and MHHs characteristics and returns differences to total food (in) security gap.

The returns (parameters) β_m and β_f are estimated using ordered probit and binary probit switching regression models. Ordered probit regression is used because the response to the question on food security is ordered in nature. However, because some of the categories have few observations relative to others, we also estimate a binary probit model to check robustness of the results. In doing this, the four categories are combined into two: food-insecure (combining chronic and transitory food insecurity) and food-secure (combining food breakeven and surplus).

Study areas, data sources and sampling procedure

More than 80% of the Malawi population lives in rural areas mainly depending on agriculture to earn their livelihoods. The agricultural sector is mainly characterized by smallholder producers and unimodal rainfall extending from December to March. The climate of Malawi is semi-arid in the lower Shire valley, semi-arid to sub humid on the plateau and sub-humid in the highlands. The largest part of the country receives 760 – 1150 mm rainfall per year. Maize is the principal food crop in Malawi, covering over 90% of the production area allocated to cereals and cereal production. Other food crops grown include rice, sorghum and millet. Legumes such as beans, pigeon-pea and groundnuts are also traditionally grown by smallholders either as mono-crops or in association with cereals mainly maize.

While many Malawian MHHs are typically advantaged compared to FHH similar to many other developing countries in terms of access to land and access to other resources (see e.g.

Chipande, 1987, Due and Gladwin, 1991; Peters, 1997; Gilbert et al., 2002; Takane, 2008, 2009), this is not uniform. The southern and central parts of the country are dominated by ethnic groups which have historically had matrilinear inheritance traditions; this might conceivably improve FHHs' access to at least some productive assets such as land (Peters, 1997; FAO, 2011). At the same time, such traditions are not static (Doss, 2001), policies both during colonial times and after independence have tended to favor male farmers (Chipande, 1987; Gilbert et al., 2002), and research has indicated that land ownership patterns have indeed changed as a result of the changing outside economic and social pressures (Takane, 2008, 2009).

The empirical analysis is based on farm household survey data collected in Malawi between March and June 2011 by the Department of Agricultural Services (DARS) of Malawi in collaboration with the International Maize and Wheat Improvement Center (CIMMYT). A multistage sampling procedure was employed to select villages from each district and households from each village. First, based on their maize-legume production potential, sixteen districts from the three regions (North, Central and South) covering various agro-ecologies were selected. Second, based on proportionate random sampling, the following selection was made: 3-16 Extension Planning Areas (EPA) in each district, 1-7 sections in each EPA, 1-5 villages in each section, and 2-8 farm households in each village. The survey covers a total of 118 EPAs, 201 sections and 397 villages. The sample contained a total of 1,920 farm households and 6, 052 plot level observations. MHHs and FHHs make up 83% and 17% (79% *de jure* and 21% *de facto* FHHs) of all the households in the sample, respectively, and 86% and 14% (78% *de jure* and 22% *de facto*) of the total 6,052 plots are operated by MHHs and FHHs, respectively.

Data and descriptive statistics

A structured questionnaire was prepared, and the sampled respondents were interviewed using trained and experienced enumerators knowledgeable of the local language. Households were asked to provide detailed description of their household, plots, and village characteristics including input and output market access, household composition, education, asset ownership including livestock ownership , various sources of income, participation in credit and off-farm activities, membership in formal and informal organizations, number of trustworthy grain traders known, current shocks/stresses experienced on crop production, participation and confidence in extension services, crop production, and land tenure. A wide range of plot-specific attributes such as soil fertility, depth, slope, farm size in hectares, and distance of the plot from the household dwelling in minutes of walking were also collected as such land attributes has implications for own production and by extension on food security status of households. This is the reason why we do the analysis at plot level.

In addition to the above mentioned variables, location variables (15 district dummies) included in the regression models. These help to capture geographic heterogeneities such as differences in spatial variation in agro-ecology, infrastructure, farming and landholding systems of the country, and differences in inheritance traditions.

The survey data collection tool specifically sought information from the respondents on how they would assess their family's food consumption in the last year taking into consideration all means (own food production, food purchase, help from different sources, food hunted from forest and lakes, etc.). Responses to this family food consumption question were given on a four point scale recorded as food shortage throughout the year (chronic food insecurity), occasional food shortage (transitory food insecurity), no food shortage but also no surplus (food break-even), and food surplus. In the MHHs both spouses were jointly interviewed on their family food security status as well as on other important variables that requires joint responses.[5]

The survey also collects information on adoption and diffusion of sustainable agricultural practices (SAPs). These include maize-legume intercropping and rotations, minimum tillage, manure, chemical fertilizer and improved crop seed varieties. For an agricultural dependent society, adoption of improved technology is a major driver of food security. A recent study by Teklewold et al., (2013) in Ethiopia showed that greater crop income increases and larger reductions in input use (fertilizer and pesticides) were associated with the joint adoption of SAPs, suggesting complementarity in benefits. Though simple regression, results show that maize yield increases with number of SAPs (see Figures 1-3).[6] Similar trend observed considering net maize income (net of fertilizer, seeds, pesticides, hired labor-results are not reported). Table 2 also demonstrates the probabilities of being chronic and transitory food insecure and food breakeven and food surplus decreases and increases, respectively, as the number of SAPs combination increases; particularly the pattern is clear for FHHs.

[Figures 1-3 about here]

[5] In 2013 we carried out individual food security status assessment, assuming there could be response differences between husband and wife because men and women could be socially conditioned to assess food security differently. The survey result, however, shows that there is no statistically significant difference in assessing their family food security status ($\chi^2 = 0.09, (p = 0.991)$).

[6] Teklewold et al. (2013) and Wollin et al. (2010) used number of SAPs as a proxy measure of intensity of adoption.

[Table 2 about here]

Although alternative definitions of head of household have recently emerged, including Hours-worked-based head, Earnings based head, and Resource control-based head (Fuwa, 2000); we used the self-reported definition of head of household. Accordingly, in the sample, 20% of the FHHs are *de facto* female headed, and 80% are *de jure* female-headed. Of the *de jure* FHHs, about 46% are divorced or separated; 53% are widowed; and 1% are single.

Definition of dependent and independent variables used in the models, with their mean values and standard deviation are reported in Table 3. For detail descriptions of independent variables see Kassie et al. (2015). Table 3 shows that FHHs are more food insecure compared with MHHs and the difference is statistically significant. About 11% (45%) of FHHs suffer from chronic (transitory) food insecurity, compared with 6% (34%) of the MHHs. The *de jure* FHHs suffer more chronic food insecurity (CF) (13%) compared with the *de facto* FHHs (7%) and the number of transitory food insecure *de facto* FHHs are higher than the *de jure* FHHs (49% Vs. 45%) though the difference is not statistically significant. About 35 % (25%) of the MHHs fall in the categories of food breakeven (surplus), compared with 29% (15%) of the FHHs. Of the total FHHs about 33 % (11%) of the *de facto* FHHs fall in food breakeven (surplus) categories, while 28% (16%) of the *de jure* FHHs do. Some 60% (44%) of the MHHs(FHHs) are food secure (combining food breakeven and surplus categories).. It seems households in the Southern region of the country seem less food secure compared to those households in the Central and Northern regions (Table 4). The South region has relatively smaller farm size compared to other regions. Notably, despite the differences in inheritance traditions across the country, regional differences in farm size are primarily driven by differences in overall population density, with FHHs farming smaller plots on average throughout the country than MHHs do. This food (in)security difference could be caused by both observed and unobserved (discrimination) characteristics of households which have implications on production. As shown in Table 3, FHHs are disadvantaged along almost every dimension of the data. They are relatively older, have less education, and smaller family sizes which may have implications for labor availability and participation in other livelihood activities (cf. e.g. Due and Gladwin, 1991; Gilbert et al., 2002; Takane 2009). They also own fewer assets (livestock, farm size, bicycle, and major household and farm equipment).

[Table 3 about here]

[Table 4 about here]

In Malawi, as in other developing countries, the availability of food and to some extent access to food is crucially determined by the productivity of farm households. Without implying any causal relationship, Figures 4-5 shows that maize yield distribution of MHHs is unambiguously dominate the maize yield distribution of *de jure* and *de facto* FHHs. Again without implying any causal relationship, the maize yield distribution of *de jure* FHHs unambiguously holds first-order stochastic dominance over *de facto* FHHs maize yield distribution (Figure 6). Though not reported here, similar results were obtained comparing the net maize income (net of fertilizer, seeds, pesticides, hired labor) distribution and per capita income distribution except the *de facto* FHHs per capita income starts dominating the *de jure* FHHs per capita income at higher level of per capita income. Cash/tree crops were grown by 60%, 43%, and 34% of the MHHs, *de facto* FHHs and *de jure* FHHs, respectively. The MHHs and the *de facto* and *de jure* FHHs allocated an average of 15%, 7%, and 11%, respectively, of their farmlands to cash/tree crops. On the other hand, the share of production area dedicated to food crops (maize and other cereals) by MHHs and *de facto* and *de jure* FHHs was 61%, 70%, and 68%, respectively. The remaining farm area is allocated to legumes and oil crops.

The unconditional summary statistics and figures above generally suggest that the issue of gender in Malawian agriculture provides for a wide range of variation in the underlying variables with heterogeneity both in access to various resources that have repercussions on the adoption of new agricultural practices such as SAPs and for their welfare, including food security. However, because food security is an outcome of the interaction of several factors, we need to add careful multivariate analysis to study the causal effect of the gender of the household head on food security.

[Figures 4-6 about here]

Empirical results: Determinants of probability of food (in)security

The estimated average marginal effects for the four food security groups and three household types (MHHs, *de jure* FHHs and *de facto* FHHs) are displayed in Tables 5a-5c.[7,8] The FHHs regression results discussion focuses on *de jure* and *de facto* FHHs results. The dependent variables are the four ordinal food security variables: chronic food insecurity, transitory food insecurity, food breakeven and food surplus.

The food security regression results show that there is an association between multiple adoption of SAPs and *de jure* FHHs and MHHs food security status. [9] The association is stronger for *de jure* FHHs than for MHHs and *de facto* FHHs. On average, a 10% increase in the adoption of SAP, decreases the number of chronic (transitory) food insecurity *de jure* FHHs and MHHs by 0.2 % (0.19%) and 0.04 % (0.09%), respectively. At the same time, it increases the number of food breakeven (surplus) *de jure* FHHs and MHHs by 0.15 % (0.24%) and 0.03 % (0.05%), respectively.[10] It does not seem there is an association between number of SAPs adoption and the probability of food security of *de facto* FHHs. Resource constraints play a big role for household food security status. For all groups, farm size has diminishing marginal effects on the probability of chronic and transitory food insecurity and increasing marginal effects on the probability of food breakeven and surplus. Ownership of a key market access and transport asset, bicycle, reduces *de jure* FHHs and MHHs likelihood of being food insecure. Though ownership of productive assets is considered to be one of the livelihood strategies for enhancing households' resilience in the face of economic crisis and adverse circumstances such as crop failure and raise living standards (Ellis 1988), livestock ownership and asset value (measured by the value of major household and farm equipment) have impact only on *de facto* FHHs and MHHs food security status.

For all groups, credit constrained households are more likely to be food insecure, indicating the importance of availing proper credit facilities in the rural villages of Malawi. There is a positive association between participation in off-farm activities and the food security status of *de facto* FHHs. The probability of being food insecure is higher for those *de*

[7] The *de facto* FHHs results should be interpreted with caution as the number of observations (66 household and 191 plot observations) are small relative to other groups.
[8] A pooled regression for FHHs (*de jure* and *de facto* combined) was run but not reported to save space.
[9] SAPs and participation in subsidy and off-farm activities could be potentially endogenous variables although comprehensive covariates including 15 location variables (district dummies) are included to capture geographic spatial differences. Further, as the adoption decision is made at planting time it is less likely to suffer from endogeneity problem. In most cases results (not reported) are stable after rerunning regression models excluding these variables.
[10] Looking at individual practices/technologies, chemical fertilizer and improved seeds play a big role in improving food security compared to other practices (results are not reported).

jure FHHs residing far from agricultural information sources (extension offices), suggesting the importance of knowledge and training in farming practices for women farmers to increase their agricultural productivity.

<Tables 5a-5c about here>

On the social capital variables, a number of trustworthy traders that farmers know in and outside the village improve the food security situation of all groups. In addition to increasing access to food, traders are important means of accessing credit, inputs, and spreading information about technologies, and offer stable market outlet services for farmers. Membership in rural institutions likewise plays an important role in the exchange of agricultural information, accessing credit in the face of market failures and the adoption of agricultural technologies among farmers (World Bank, 2013). Consistent with previous studies (e.g. Due and Gladwin, 1991; Kassie et al. 2014), membership in rural institutions/associations increased the probability of *de jure* FHHs being food secure, while the *de facto* FHHs food security increases with the number of relatives in and outside the village that households rely on in critical times. We also control for the possible role of farmers' perception of government assistance by including a dummy variable equal to one if a household believes that it can rely on government support when events beyond their control occur and cause output or income loss. It positively influences the food security status of *de jure* FHHs. In the developing world where production risks are high due to a number of factors (e.g., unreliable rainfall, incidence of pests and diseases), farmers are less likely to adopt various livelihood strategies in the absence of consumption smoothing insurance during production failure.

As for plot characteristics, *de jure* FHHs and MHHs operating on flat and medium slope plots are, not surprisingly, more likely to be food secure than those operating on steep plots. We find shallow depth soil plots and plot distance from residence to have negative association with *de jure* FHHs food security. However, we find flat slope plots and medium soil depth plots seem to increase *de facto* FHHs probability of food insecurity. This is probably because of unobserved plot characteristics.

On household's characteristics, education of household head has a positive relationship with MHHs food security status where better educated households are likely to improve their food security outcomes. For all groups, household with greater family size seem to suffer from greater food insecurity.

The results further underscore the importance of rainfall and plot level shocks in determining the household food security status. In areas/years where rainfall is reliable in terms of timing, amount and distribution, it is more likely that FHHs improve their food security; suggesting that promoting and encouraging adoption of water harvesting strategies by FHHs could sustain their food security status. However, there is a negative association between non-rainfall shocks (pests, disease, drought, waterlogging) occurrence and MHHs food security.

Gendered food security gap: Contribution of observed characteristics and returns to characteristics

The results of the decomposition analysis for the exogenous switching regression with ordered probit model are presented in Tables 6a-6c.[11] Our results discussion focuses on *de jure* FHHs as we have a relatively adequate number of observations for these compared to *de facto* FHHs where the number of observations is small.

Comparing the actual values of expected food security status (cell ‘a’ with cell ‘b’ of Table 6a) shows that the difference in MHHs’ and *de jure* FHHs’ chronic (transitory) food insecurity and food breakeven (surplus) is 5.8 (10.8) and 7.8 (8.8) percentage points, respectively. However, comparing these values are misleading without taking into account their differences in observed and unobserved characteristics. This requires the computation of the counterfactual expected values (cells c and d). The counterfactual analysis reveals that the FHHs’ food security status would significantly improve if their currently observed characteristics had the same returns as MHHs current characteristics. The impact is higher for *de facto* FHHs than for *de jure* FHHs. With similar returns to characteristics, the observed gap indicated above would be reduced to 3.3 (5.7) and 2.2% (4.6) percentage points, respectively (compare cell ‘a’ and‘d’ of Table 6a). This is the level effects in the last row of table 6a.).

Similarly, if the *de jure* FHHs’ current observed characteristics had the same returns as those of the MHHs (cell d), the number of *de jure* FHH falling into chronic (transitory) food insecurity would have declined by 2.5 (5.1) percentage points and food breakeven (surplus) would have increased by 5.6 (2.0) percentage points (Compare cells marked with‘d’

[11] As mentioned on foot note 8, the food security gaps estimated with and without potential endogenous variables. The qualitative results (not reported) excluding these variables are similar in the case where food security gap is estimated including these variables.

and ‘b’, respectively). This is the returns effect. The qualitative results are the same for pooled FHHs (all FHHs) and *de facto* FHHs (except in the case of chronic food insecurity where the counterfactual is higher than the actual for *de facto* FHHs). Results in Table 6b also show that had the MHHs’ observed characteristics had the same returns as those of the FHHs, their probability of food security status would have declined (compare cells marked with ‘a’ and ‘c’). The number of MHHs falling into chronic (transitory) food insecurity would have increased by 4.4 (5.5) percentage points and the food breakeven (surplus) would have decreased by 5.6 (4.2) percentage points. These results reveal that the level and quality of FHHs resources are relatively lower than MHHs.

Using equation (8) and focusing on *de jure* FHHs results, the estimated results indicate that 57% (53%)of the total chronic (transitory) food insecurity gap is explained by observable differences in FHHs and MHHs resources use, and the remaining 43% (47%) is attributable to gender differences in returns to resources use. The same interpretation applies for food breakeven and surplus indicators gap. In this case, 28% (77%) of the total gap in food breakeven and surplus results from gender differences in resources use, while 72% (23%) is attributable to differences in the returns to this resources use. The results from all FHHs and *de facto* FHHs can be discussed in the same fashion.

<Tables 6a-6c about here>

The binary food security estimates from probit switching regression model tells a similar story[12]. Almost the same number and type of covariates influence the food security status of *de jure* FHHs and MHHs as in the ordered probit model results.[13] On food security gap, the numbers of food secure *de jure* FHHs would increase by 6.0 (0.445 to 0.505) percentage points when their characteristics had same returns as MHHs. About 37% and 63% of the gender gap is resulted from returns to resources use and differences in the level of resources use.[14]

Overall, the results imply that closing the gendered food security gap requires creating opportunities for FHHs to have not only equal access to key resources but also to benefit the

[12] The regression results are not reported here but available from the authors upon request.
[13] On *de facto* FHHs about 50 observations dropped because of prefect collinearity between some of the district variables and outcome variable and thus the probit regression model was not estimated.
[14] We find very close results using the nonlinear wage decomposition command (nldecompose). The gendered food security gap due to differences in resource use and returns to resource use is respectively 66% and 34%. This command cannot also be used for ordinal outcome variables but it doesn’t produce results for each category and thus we did not compare results of ordered probit model.

same way from their resources as MHHs. These findings have important implications for policy-makers who seek socially-inclusive growth.

Concluding remarks

Gender inequality in food (in)security has received increased empirical and policy attention. Understanding what causes the gendered food security gap is crucial for identifying the right policies and programs that can empower women farmers and support them in their efforts to increase food production and food security status. Previous research on the links between gender and food security did not look closely at how both gender differences in resources and returns to these resources contributed to the food security gap. The objective of this paper was to understand factors deriving households' food security and determine the sources of the gendered food security gap as well as to measure their relative importance. In doing so, we apply exogenous ordered switching regression model in a counterfactual framework using gender of the household head as a treatment variable. This method decomposes the gendered food security gap into the gender gap caused by differences in the quantity of resources use and in returns to resources use.

The gendered food security gap analysis reveals, not surprisingly, the level of resource use is lower among FHHs than among MHHs, which causes a food security disparity. More importantly, the econometric results suggest that even under counterfactual conditions where FHHs are given the same levels of resource access and use as MHHs, the probability that they will be food insecure (chronic or transitory) remains high, and the probability that they will be food secure (food breakeven or surplus) remains low compared to MHHs. These results highlight the presence of gender inequalities against women in the form of limited access to credit, extension, information and water sources, and discrimination in the form of more limited access to land and quality land. Reducing one of these forms of discrimination (e.g. targeting differences in resource access only) would improve FHHs' food security status but would not lead to equality, unless accompanied by policies that target the other forms of discrimination (which affect the returns to resources use) as well.

These results are important for policy makers and other development practitioners for understanding the separate contributions of sets of factors affecting the gendered gap and devising appropriate policies that could effectively help the fight against food insecurity and poverty. Based on our results, multiple SAPs adoption has a greater impact on *de jure* FHHs to escape food insecurity than on MHHs and *de facto* FHHs. From a policy perspective, although FHHs could become an easily identifiable group on which to target poverty alleviation measures through adoption of multiple SAPs, it would be a mistake to underestimate the role of unobservable and other observable factors important for reducing gender discrimination in productive resources which are complementary with SAPs for raising the household food security status.

A much more precise understanding of factors influencing household food security status may also help policy makers establish food security policies that target FHHs and MHHs with a more efficient allocation of resources to the policies. Most importantly, the results show that the probability to escape from food insecurity or achieving food security are influenced by several factors: social capital in the form of membership of rural institutions and number of traders known by the farmer in and outside his village, credit, information and off-farm activity access, physical resource access, rainfall and plot-level disturbances, and belief in government support in case of crop failure. Especially social safety nets (government support during crop failure) and social capital are important policy variables with high impacts on improving technology and food security. The significant role of some of the social capital indicates that the root of poverty is not only lack of money, but also lack of social networks and support included in social capital (Due and Gladwin, 1991; Martin et al., 2004). Hence, rather than simply focusing on food assistance programs, policy makers need to focus on establishing and strengthening appropriate social institutions that can increase the speed of technology adoption, increase farm productivity and thereby improve household food security.

The significant impacts of physical assets ownership (farm size, bicycle) and farm characteristics and credit constraints suggests that assisting women farmers in improving the quality of their land and involving them in asset building and micro-finance programs. Improving women (particularly *de jure* FHHs) access to agricultural information is also important for improving their productivity and food security performance.

Finally, this study is based on cross-sectional survey data which may not adequately take into account the dynamics of food security and factors (including dynamics of technology adoption) influencing this; however, both smallholder farming and the gender roles in farming are constantly changing in response to changes in outside economic and social pressures (Doss, 2001; Takane, 2008); one indication of this is that despite historical regional differences in inheritance traditions, current land ownership is consistently biased in favor of MHHs throughout Malawi . Further research, using panel data, is important for capturing these dynamics, as well as for capturing unobserved household and time specific heterogeneity.

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References

Angner, E., 2010. Subjective well-being. J. Socio-Economics. 39, 361-368.

Babatunde R.O. Omotesho O.A. Olorunsanya E.O. and Owotoki G.M., 2008. Determinants of food insecurity: A gender based analysis of farming households in Nigeria. Indian J. Agric. Econ. 63, 116-125.

Barros, R., Fox, L., & Mendonça, R., 1997. Female-headed households, poverty, and welfare of children in urban Brazil. Econ.Deve. and Cultural Change, 45(2), 231–257.

Buvinić, M., & Rao Gupta, G., 1997. Female-headed households and female-maintained families: Are they worth targeting to reduce poverty in developing countries. Econ. Deve. and Cultural Change. 45, 259–280.

Chipande, G.H.R., 1987. Innovation adoption among female-headed households: The case of Malawi. Development and Change 18 (2), 315 – 327.

Deaton, A.,2010. Price indices, inequality, and the measurement of world poverty, Presidential Address, American Economic Association, January, Atlanta.

Dolan, C. S., (2004) I Sell My Labour Now: Gender and Livelihood Diversification in Uganda. *Canadian Journal of Development Studies*. 25(4), 643-61.

Doss, C. R. 2001- Designing agricultural technology for African women farmers: lessons from 25 years of experience. World Development 29(12), 2075-2092.

Due, J. M. and Gladwin, C. H. 1991. Impacts of structural adjustment programs on African women farmers and female-headed households. American Journal of Agricultural Economics 73, 1431-1439.

Ellis F., 1998. Household strategies and rural livelihood diversification. J. Deve. Studies. 35, 1-38.

FAO. 2011. Food and Agriculture Organization of the United Nations: Gender Inequalities in Rural Employment in Malawi: An Overview. Rome: FAO, 2011

Frey, B.S. and Stutzer, A., 2002.What Can Economists Learn from Happiness Research? J. Econ. Literature. 40(2), 402-435.

Fuwa, N., 2000. The poverty and heterogeneity among female-headed households revisited: The case of Panama. World Deve. 28(8), 1515–1542.

Gilbert, R.A., Sakala, W.D., and Benson, T.D., 2002. Gender analysis of a nationwide cropping system trial survey in Malawi. *African Studies Quarterly*. 6 (1 – 2), 223 – 243.

IRIN (2006). Integrated Regional Information Networks, Southern Africa: Female headed households most vulnerable to food insecurity (Available at http://www.irinnews.org/Report/50852/).

Kahneman, D. and Krueger, A B., 2006.Developments in the Measurement of Subjective Well-Being. *The Journal of Economic Perspectives*. 20(1),3-24.

Kassie, M., Hailemariam, T, Moti, J., Marenya, P. and Erenstein, O. 2015. Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. Land use Policy, 42: 400-411

Kassie M., Ndiritu, S.W. and Stage, J.,2014. What determines Gender Inequality in Household Food Security in Kenya? Application of Exogenous Switching Treatment Regression. *World Deve.* 56,.153-171.

Kennedy, E. and Peters, P., 1992.Household Food Security and Child Nutrition: The Interaction of Income and Gender of Household Head. *World Deve.* 20(8), 1077-1085.

Mallick D. and Rafi M., 2010. Are Female-Headed Households More Food Insecure? Evidence from Bangladesh. *World Deve.* 38,593-605.

Mark, B.; Sudharshan, C.; Stephan, K.; David, L.,2006. Gender and growth in Sub-Saharan Africa: Issues and evidence. Research Paper, UNU-WIDER, United Nations University (UNU), No. 2006/37, ISBN 9291908053.

Martin K.S., Rogers B.L., Cook J.T., Joseph H.M., 2004. Social capital is associated with decreased risk of hunger. Social Science & Medicine. 58, 2645–2654.

Meinzen-Dick, R., A. Quisumbing, J.Behrman, P. Biermayr-Jenzano, V. Wilde, M.Noordeloos, C. Ragasa, and N. Beintema.,2011. Engendering Agricultural Research, Development and Extension. IFPRI research monograph. Washington, D.C., IFPRI, 2011).

Minot, N., Kherallah, M. and Berry, P., 2000. Fertilizer market reform and the determinants of fertilizer use in Benin and Malawi. MSSD discussion paper 40, IFPRI.

Onjala, J., Ndiritu, S. W. and Stage, J. (2014). Risk perception, choice of drinking water and water treatment: evidence from Kenyan towns. *Journal of Water, Sanitation and Hygiene for Development* 4 (2), 268 – 280

Peters, P.E.,1995.Uses and Abuses of the Concept of 'Female-headed Households' in Research on Agrarian Transformation and Policy, in D. F. Bryceson (ed.), *Women Wielding the Hoe: Lessons from Rural Africa for Feminist Theory and Development Practice*, pp. 93-108. Oxford: Berg.

Peters, P. E., 1997. Against the odds: Matriliny, land and gender in the Shire highlands of Malawi. Critique of Anthropology 17 (2), 189-210

Phiri, C. 1986. Women and their economic activities: A comparative analysis of male-headed and female-headed households in Thekerani Rural Growth Centre. Department of Rural Development, Bunda College, Zomba, Malawi. Cited in Due and Gladwin (1991).

Quisumbing, A. R., Haddad, L., and Pen˘ a, C., 2001. Are women overrepresented among the poor? An analysis of poverty in 10 developing countries. *J. Deve. Econ.* 66, 225–269.

Quisumbing, A. R.,1995. Gender differences in agricultural productivity: Survey of empirical evidence. FCND Discussion Paper No. 5. Washington, D. C.: Food Consumption and Nutrition Division, International Food Policy Research Institute.

Ravallion, M. and Lokshin, M.,2002. Self-rated economic welfare in Russia. *European Econ. Rev*. 46(8), 1453-73.

Stutzer, A.s and Frey, B. S.,2010. Recent Advances in the Economics of Individual Subjective Well-Being. Institute for the Study of Labour (IZA) Discussion Paper No. 4850.

Takane, T. 2008. Customary land tenure, inheritance rules and smallholder farmers in Malawi. Journal of Southern African Studies 34 (2): 269-291.

Takane, T. 2009. Disparities and diversities among female-headed households in rural Malawi after 20 years of economic liberalization. Singapore Journal of Tropical Geography 30: 358-372.

Teklewold, H., Kassie, M., Shiferaw, B.,2013.Adoption of multiple sustainable agricultural practices in rural Ethiopia. J. Agric. Econ. 64(3), 597–623.

The Economist Intelligence Unit, 2012, Global food security index 2012. A report from the Economist Intelligence Unit.

van Praag, B. M. S., Frijters, P., andFerrer-i-Carbonell, A.,2003. The anatomy of subjective well-being. J. *Econ. Behavior & Organization*, 51(1), 29–49.

van Hoorn, A.; Mabsout, R. and Sent, E-M.,2010.Happiness and Capability: Introduction to the Symposium. J.Socio-Economics. 39, 339-334.

Wollni M., Lee D.R., and Janice L.T., 2010.Conservation agriculture, organic marketing, and collective action in the Honduran hillsides. Agric. Econ. 41,373–384.

World Bank,2013. Levelling the field: Improving Opportunities for Women Farmers in Africa

World Bank.2001. Engendering Development: Through Gender Equality in Rights, Resources, and Voice, A World Bank Policy Research Report, World Bank: Washington DC.

World Bank.2000. Can Africa Claim the 21st Century?, report prepared jointly by the African Development Bank, African Economic Research Consortium, Global Coalition for Africa, Economic Commission for Africa, and the World Bank, World Bank: Washington DC.

Table 1: Conditional expectations, Levels and Returns effects

Household types	Male-headed households (MHHs)	Female-headed households (FHHs)	Return effects
Male-headed households	$a)\ E(S_m \mid g=1)$	$c)\ E(S_f \mid g=1)$	(a – c)
Female-headed households	$d)\ E(S_m \mid g=0)$	$b)\ E(S_f \mid g=0)$	(d – b)
Levels effects	(a – d)	(c – b)	

Notes: Cells *a)* and *b)* denote the food security status that is actually observed in a sample (refers to equation 4a) and 4b) in the method section); cells *c)* and *d)* (equivalent to equation 4c and 4d in the method section) denote the counterfactual food security status; $G = 1$ if the household head is male; $G = 0$ if the household head is female; S_m = food security status indicator for MHHs; S_f = food security status indicator for FHHs;

Table 2. Distribution of household food security status by gender and number of SIPs adopted (% in food security status)

Gender	Food security status	Number of SIPs adopted					Total
		≤ 1	2	3	4	≥ 5	
FHH	Chronic food insecurity (CF)	13.92	17.31	8.10	8.92	9.57	11.21
	Transitory food insecurity (TF)	48.10	46.79	47.14	42.04	40.43	45.11
	Food break-even (BF)	27.85	25.00	29.05	30.57	32.98	28.88
	Food surplus (SF)	10.13	10.90	15.71	18.47	17.02	14.80
de jure FHH	Chronic food insecurity (CF)	14.71	18.90	9.25	11.21	10.67	12.70
	Transitory food insecurity (TF)	52.94	47.24	43.35	40.52	40.00	44.36
	Food break-even (BF)	23.53	22.05	30.64	30.17	29.33	27.55
	Food surplus (SF)	8.82	11.81	16.76	18.10	20.00	15.38
de facto FHH	Chronic food insecurity (CF)	9.09	10.34	2.70	2.44	5.26	5.11
	Transitory food insecurity (TF)	18.18	44.83	64.86	46.34	42.11	48.18
	Food break-even (BF)	54.55	37.93	21.62	31.71	47.37	34.31
	Food surplus (SF)	18.18	6.90	10.81	19.51	5.26	12.41
MHH	Chronic food insecurity (CF)	6.38	5.92	6.83	3.92	4.81	5.68
	Transitory food insecurity (TF)	30.32	35.24	33.56	31.83	35.70	33.53
	Food break-even (BF)	43.09	34.73	34.59	35.99	32.27	35.51
	Food surplus (SF)	20.21	24.11	25.02	28.27	27.23	25.28

Table 3. Description and summary statistics of the variables used in the analysis by gender and food security status

Variable	Description	Gender				Mean difference
		FHH		MHH		(A – B)
		Mean	SD	Mean	SD	
		A		B		
	Outcome variables					
Food security	Household food security status (1=food secure; 0= food insecure)	0.44		0.60		-0.16***
Chronic food insecurity	Household suffer from chronic food security(1=yes; 0=no)	0.11		0.06		0.05***
Transitory food insecurity	Household suffer from transitory food security(1=yes; 0=no)	0.45		0.34		0.12***
Food breakeven	Household has food break-even (1=yes; 0=no)	0.29		0.35		-0.07**
Food surplus	Household has food surplus(1=yes; 0=no)	0.15		0.25		-0.10***
	Human capital					
Age	Age of the head (years)	45.54	16.22	41.95	13.83	3.59***
Educhead	Education level of the head (years of schooling)	4.10	3.51	6.20	3.68	-2.09***
Famlysize	Total family size (number)	4.19	1.82	5.43	2.16	-1.24***
	Resource constraints					
Farmsize	Farm size, acres	2.69	1.59	3.77	3.35	-1.08***
Assetvalue	Total value of assets (‘000 MK)	5.69	14.48	18.50	180.66	-12.02**
TLU	Livestock size (in tropical livestock units)	0.35	0.47	0.73	0.40	-0.39***
Bicycle	1=if owned bicycle	0.23		0.59		-0.37***
Offfarm	1=if participated in off-farm activities	0.46		0.53		-0.09***
Credit	1=if credit constraint (credit is needed but unable to get)	0.68		0.68		-0.002
Subsidy	1=if household get fertilizer subsidy	0.82		0.76		0.06***
Cashcrop	1=if farmer grows cash (vegetable, fruit, cotton, tobacco) crops	0.38		0.60		-0.22
	Market access and extension					
Mktdist	Walking distance to main markets, minutes	36.15	26.47	36.24	29.40	-0.09
Distwatr	Walking distance to fetch water, minutes	6.61	6.33	6.59	6.52	0.01
Distexte	Walking distance to extension agents office, minutes	8.94	30.34	13.72	45.42	-4.79***
	Social and political capital					
Trader	Number of grain traders that farmers know and trust	8.42	9.02	9.48	9.04	-1.06***
Kinship	Number of close relatives living in and outside the village that household rely on in critical times	6.32	5.81	6.50	5.45	0.18
Member	1=if member in input/marketing/labor rural institutions/group	0.40		0.58		0.18***
	Shocks					
Govtsup	1=if believe in government support in case of crop failure	0.59		0.56		0.03*
Rainshock	Rainfall shock index (1=Best)	0.60	0.26	0.63	0.27	-0.04***
Nonrainshock	Non-rainfall shock index (1=Worst)	0.17	0.13	0.16	0.13	0.01***
	Natural capital					

Plotdist	Plot distance from home, minutes	18.49	20.03	19.53	21.58	-1.03
Tenure	1=if owned the plot	0.96		0.95		0.01
Goodsoil[a]	1=if farmers' perception that plot has good fertile soil	0.39		0.47		-0.08***
Medumsoil[a]	1=if farmers' perception that plot has medium fertile soil	0.43		0.40		0.03*
Flatslop[b]	1=if farmers' perception that plot has flat slop	0.62		0.62		-0.001
Medumslop[b]	1=if farmers' perception that plot has medium flat slope	0.26		0.28		-0.01
Shalwdepth[c]	1=if farmers' perception that plot has shallow soil	0.21		0.16		0.05***
Medumdepth[c]	1=if farmers' perception that plot has medium deep soil	0.44		0.40		0.04**
Adioption of number of SAPs	Number of SAPs adopted	3.04	1.20	3.00	1.15	0.05
Location variables (15 district dummies)						
Number of plot (household) observations		873 (321)				5179 (1599)

Note: [a]plots with poor soil quality are the reference category; [b]plots with steep slope are the reference category; [c]plots with deep depth soil are the reference category; CF=Chronic food insecurity status; TF=Transitory food insecurity; BF=Break-even food security; SF=Food security; *, ** and *** indicate statistical significance at 10%, 5% and 1%, respectively.

Table 4. Farm size and Food security distribution by region

region	Total farm size (acre)	Proportion of households (%)				
		Food secure households(1=yes)	Chronic food insecure households	Transitory food insecure households	Food breakeven households	Food surplus households
North	4.34	62	2	35.6	38.9	23.4
Central	3.90	63	5	31.6	36.7	26.6
South	2.94	46	10.8	42.8	29.2	17.2

Table 5a. Ordered probit model results (Male headed households-MHHs)

	Chronic food insecurity			Transitory food insecurity			Food Breakeven			Food surplus		
	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z
Human capital												
Age	0.000	0.000	0.703	0.000	0.001	0.702	0.000	0.000	0.703	0.000	0.001	0.703
Educhead	-0.003	0.001	0.002[a]	-0.007	0.002	0.002[a]	0.002	0.001	0.003[a]	0.008	0.002	0.002[a]
lnFamlysize	0.058	0.011	0.000[a]	0.130	0.023	0.000[a]	-0.036	0.007	0.000[a]	-0.152	0.027	0.000[a]
Resource constraints												
Lnfarmsize	-0.050	0.009	0.000[a]	-0.111	0.020	0.000[a]	0.031	0.006	0.000[a]	0.131	0.023	0.000[a]
lnAssetvalue	-0.025	0.004	0.000[a]	-0.056	0.008	0.000[a]	0.015	0.003	0.000[a]	0.065	0.010	0.000[a]
TLU	-0.005	0.002	0.032[b]	-0.011	0.005	0.028[b]	0.003	0.001	0.035[b]	0.013	0.006	0.028[b]
Bicycle	-0.018	0.007	0.005[a]	-0.041	0.015	0.005[a]	0.011	0.004	0.007[a]	0.048	0.017	0.005[a]
Offfarm	-0.010	0.007	0.124	-0.022	0.014	0.119	0.006	0.004	0.126	0.026	0.017	0.119
Credit	0.012	0.007	0.089[c]	0.026	0.015	0.091[c]	-0.007	0.004	0.097[c]	-0.030	0.018	0.090[c]
Subsidy	-0.018	0.008	0.022[b]	-0.039	0.017	0.019[b]	0.011	0.005	0.023[b]	0.046	0.020	0.020[b]
Acees to services												
Mainmktdist	0.000	0.000	0.198	0.000	0.000	0.195	0.000	0.000	0.201	0.000	0.000	0.195
Distexte	0.000	0.000	0.683	0.000	0.000	0.683	0.000	0.000	0.684	0.000	0.000	0.683
Distwatr	-0.001	0.001	0.043[b]	-0.003	0.001	0.043[b]	0.001	0.000	0.044[b]	0.003	0.001	0.043[b]
Social capital and network												

Trader	-0.002	0.000	0.000[a]	-0.004	0.001	0.000[a]	0.001	0.000	0.000[a]	0.004	0.001	0.000[a]
Kinship	0.000	0.001	0.677	-0.001	0.001	0.676	0.000	0.000	0.677	0.001	0.002	0.676
Member	0.001	0.004	0.820	0.002	0.009	0.820	-0.001	0.003	0.820	-0.003	0.011	0.820
Govtsup	0.002	0.007	0.804	0.004	0.015	0.804	-0.001	0.004	0.804	-0.004	0.017	0.804
Shocks												
Rainshock	-0.004	0.013	0.785	-0.008	0.029	0.785	0.002	0.008	0.785	0.009	0.034	0.785
Nonrainshock	0.096	0.026	0.000[a]	0.214	0.055	0.000[a]	-0.059	0.016	0.000[a]	-0.251	0.065	0.000[a]
Natural capital												
Plotdist	0.000	0.000	0.016[b]	-0.001	0.000	0.013[b]	0.000	0.000	0.017[b]	0.001	0.000	0.013[b]
Tenure	-0.003	0.012	0.816	-0.006	0.026	0.816	0.002	0.007	0.816	0.007	0.030	0.816
Goodsoil	0.000	0.009	0.961	-0.001	0.020	0.961	0.000	0.005	0.961	0.001	0.023	0.961
Medumsoil	0.000	0.009	0.983	0.000	0.020	0.983	0.000	0.005	0.983	-0.001	0.023	0.983
Flatslop	-0.020	0.009	0.023[b]	-0.045	0.020	0.022[b]	0.012	0.006	0.028[b]	0.053	0.023	0.021[b]
Medumslop	-0.016	0.009	0.087[c]	-0.035	0.021	0.087[c]	0.010	0.006	0.094[c]	0.042	0.024	0.086[c]
Shalwdepth	0.005	0.008	0.526	0.012	0.018	0.523	-0.003	0.005	0.524	-0.014	0.022	0.524
Medumdepth	0.008	0.006	0.171	0.019	0.014	0.171	-0.005	0.004	0.170	-0.022	0.016	0.171
Cashcrop	0.009	0.007	0.156	0.021	0.014	0.150	-0.006	0.004	0.166	-0.024	0.017	0.149
Adoption of number of SAPs	-0.004	0.002	0.030[b]	-0.009	0.004	0.025[b]	0.003	0.001	0.030[b]	0.011	0.005	0.026[b]
Location variables (15 district dummies)	Yes			Yes			Yes			Yes		
Number of plot (household) observations	5179 (1599)											
Overall model significance statistics												
Wald chi2	372.31[a]											
Pseudo R2	0.1085											
Log pseudolikelihood	-5756.43											

Note: a, b, and c implies significance level at 1, 5, and 10% respectively.

n

Table 5b. Ordered probit model results (*de jure* female headed households)

	Chronic food insecurity			Transitory food insecurity			Food Breakeven			Food surplus		
	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z
Human capital												
Age	0.001	0.001	0.242	0.001	0.001	0.242	0.000	0.000	0.240	-0.001	0.001	0.242
Educhead	0.000	0.003	0.936	0.000	0.003	0.936	0.000	0.002	0.936	0.000	0.004	0.936
lnFamlysize	0.083	0.023	0.000[a]	0.079	0.021	0.000[a]	-0.062	0.017	0.000[a]	-0.100	0.027	0.000[a]
Resource constraints												
Lnfarmsize	-0.083	0.023	0.000[a]	-0.079	0.022	0.000[a]	0.062	0.017	0.000[a]	0.100	0.028	0.000[a]
lnAssetvalue	-0.011	0.010	0.259	-0.011	0.010	0.260	0.008	0.007	0.259	0.014	0.012	0.259
TLU	0.001	0.009	0.944	0.001	0.009	0.944	0.000	0.007	0.944	-0.001	0.011	0.944
Bicycle	-0.054	0.021	0.008[a]	-0.052	0.019	0.008[a]	0.041	0.015	0.008[a]	0.065	0.024	0.007[a]
Offfarm	0.011	0.016	0.473	0.011	0.015	0.473	-0.009	0.012	0.473	-0.014	0.019	0.473
Credit	0.031	0.017	0.065[c]	0.030	0.016	0.065[c]	-0.023	0.013	0.064[b]	-0.037	0.020	0.064[c]
Subsidy	-0.013	0.021	0.541	-0.012	0.020	0.542	0.009	0.015	0.541	0.015	0.025	0.542
Access to services												
Mainmktdist	0.000	0.000	0.468	0.000	0.000	0.467	0.000	0.000	0.467	0.000	0.000	0.468
Distexte	0.001	0.000	0.022[b]	0.001	0.000	0.023[b]	-0.001	0.000	0.023[b]	-0.001	0.000	0.022[b]
Distwatr	-0.001	0.001	0.534	-0.001	0.001	0.534	0.001	0.001	0.534	0.001	0.001	0.534
Social capital and network												
Trader	-0.002	0.001	0.040[b]	-0.002	0.001	0.040[b]	0.001	0.001	0.040[b]	0.002	0.001	0.039[b]
Kinship	-0.002	0.001	0.141	-0.002	0.001	0.141	0.001	0.001	0.140	0.002	0.002	0.141
Member	-0.027	0.013	0.042[b]	-0.026	0.013	0.041[b]	0.020	0.010	0.040[b]	0.033	0.016	0.042[b]
Govtsup	-0.075	0.017	0.000[a]	-0.072	0.016	0.000[a]	0.056	0.013	0.000[a]	0.091	0.020	0.000[a]
Shocks												
Rainshock	-0.092	0.031	0.003[a]	-0.087	0.029	0.003[a]	0.069	0.023	0.003[a]	0.110	0.037	0.003[a]
Nonrainshock	0.001	0.061	0.990	0.001	0.059	0.990	-0.001	0.046	0.990	-0.001	0.074	0.990
Natural capital												

Plotdist	0.001	0.000	0.053[c]	0.001	0.000	0.055[c]	-0.001	0.000	0.054[c]	-0.001	0.000	0.053[a]
Tenure	0.059	0.033	0.070[c]	0.057	0.031	0.071[c]	-0.044	0.025	0.073[c]	-0.072	0.039	0.069[c]
Goodsoil	-0.030	0.024	0.210	-0.028	0.023	0.214	0.022	0.018	0.212	0.036	0.029	0.211
Medumsoil	-0.027	0.023	0.233	-0.026	0.022	0.238	0.020	0.017	0.235	0.033	0.027	0.235
Flatslop	-0.070	0.025	0.005[a]	-0.067	0.024	0.005[a]	0.052	0.018	0.004[a]	0.084	0.030	0.005[a]
Medumslop	-0.076	0.026	0.004[a]	-0.072	0.025	0.004[a]	0.057	0.020	0.004[a]	0.092	0.032	0.004[a]
Shalwdepth	0.053	0.021	0.013[b]	0.051	0.021	0.014[b]	-0.040	0.016	0.013[b]	-0.064	0.026	0.013[b]
Medumdepth	0.013	0.017	0.457	0.012	0.016	0.458	-0.009	0.013	0.458	-0.015	0.021	0.458
Cashcrop	-0.004	0.016	0.813	-0.004	0.015	0.813	0.003	0.012	0.813	0.005	0.019	0.813
Adoption of Number of SAPs	-0.020	0.006	0.002[a]	-0.019	0.006	0.002[a]	0.015	0.005	0.002[a]	0.024	0.008	0.002[a]
Location variables (15 district dummies)	Yes			Yes			Yes			Yes		
Number of plot (household) observations	682 (255)											
Overall model significance statistics												
Wald chi2	270.150[a]											
Pseudo R2	0.157											
Log pseudolikelihood	-724.41											

Note: a, b, and c implies significance level at 1, 5, and 10% respectively.

Table 5c. Ordered probit model results (*de facto* female headed households)

	Chronic food insecurity			Transitory food insecurity			Food Breakeven			Food surplus		
	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z	Average marginal effects	Std. Err.	P>z
Human capital												
Age	0.003	0.001	0.017b	0.004	0.002	0.008[a]	-0.003	0.001	0.027[b]	-0.004	0.002	0.012[b]
Educhead	0.017	0.005	0.000[a]	0.025	0.007	0.001[a]	-0.016	0.006	0.005[a]	-0.026	0.007	0.001[a]
lnFamlysize	-0.017	0.039	0.672	-0.024	0.056	0.671	0.016	0.037	0.673	0.025	0.059	0.671
Resource constraints												
Lnfarmsize	-0.172	0.044	0.000[a]	-0.246	0.077	0.001[a]	0.161	0.065	0.014[b]	0.257	0.066	0.000[a]
lnAssetvalue	-0.067	0.019	0.000[a]	-0.096	0.029	0.001[a]	0.063	0.025	0.011[b]	0.100	0.027	0.000[a]
TLU	-0.061	0.031	0.050[b]	-0.087	0.038	0.023[b]	0.057	0.029	0.054[c]	0.091	0.043	0.033[b]
Bicycle	0.182	0.040	0.000[a]	0.260	0.060	0.000[a]	-0.170	0.058	0.003[a]	-0.272	0.055	0.000[a]
Offfarm	-0.055	0.027	0.040[b]	-0.079	0.038	0.038[b]	0.052	0.028	0.065[c]	0.083	0.040	0.036[b]
Credit	0.084	0.025	0.001[a]	0.120	0.038	0.002[a]	-0.078	0.032	0.015[b]	-0.125	0.036	0.001[a]
Subsidy	-0.023	0.021	0.280	-0.033	0.032	0.295	0.022	0.021	0.301	0.035	0.033	0.289
Acees to services												
Mainmktdist	0.000	0.000	0.679	0.000	0.000	0.666	0.000	0.000	0.674	0.000	0.000	0.671
Distexte	0.000	0.000	0.155	0.001	0.000	0.171	0.000	0.000	0.181	-0.001	0.000	0.167
Distwatr	-0.003	0.002	0.042[b]	-0.005	0.002	0.052[b]	0.003	0.002	0.097[c]	0.005	0.002	0.033[b]
Social capital and network												
Trader	-0.006	0.003	0.011[b]	-0.009	0.003	0.004[a]	0.006	0.002	0.016[b]	0.010	0.004	0.008[a]
Kinship	-0.010	0.004	0.006[a]	-0.014	0.005	0.003[a]	0.009	0.004	0.024[b]	0.015	0.005	0.002[a]
Member	-0.018	0.018	0.316	-0.026	0.027	0.346	0.017	0.019	0.364	0.027	0.027	0.321
Govtsup	-0.042	0.027	0.121	-0.061	0.040	0.131	0.039	0.028	0.157	0.063	0.041	0.121
Shocks												
Rainshock	-0.169	0.068	0.013[a]	-0.241	0.086	0.005[a]	0.158	0.072	0.028[b]	0.253	0.091	0.006[a]
Nonrainshock	-0.222	0.111	0.046[c]	-0.318	0.151	0.035[b]	0.208	0.120	0.083[c]	0.333	0.151	0.027[b]
Natural capital												
Plotdist	-0.001	0.001	0.183	-0.001	0.001	0.161	0.001	0.001	0.203	0.001	0.001	0.161

Tenure	0.009	0.048	0.855	0.013	0.069	0.857	-0.008	0.045	0.856	-0.013	0.072	0.856
Goodsoil	-0.064	0.033	0.051[c]	-0.092	0.054	0.087[c]	0.060	0.039	0.123	0.096	0.050	0.054[c]
Medumsoil	-0.018	0.025	0.462	-0.026	0.037	0.481	0.017	0.025	0.487	0.027	0.038	0.468
Flatslop	0.094	0.033	0.004[a]	0.135	0.050	0.007[a]	-0.088	0.040	0.029[b]	-0.141	0.048	0.003[a]
Medumslop	0.037	0.036	0.302	0.053	0.051	0.299	-0.035	0.035	0.325	-0.056	0.053	0.291
Shalwdepth	0.041	0.024	0.096[c]	0.058	0.035	0.092[c]	-0.038	0.024	0.111	-0.061	0.037	0.097[c]
Medumdepth	0.084	0.028	0.003[a]	0.120	0.041	0.003[a]	-0.078	0.032	0.015[b]	-0.125	0.042	0.003[a]
Cashcrop	0.045	0.022	0.040[b]	0.065	0.033	0.052[c]	-0.042	0.025	0.093[c]	-0.068	0.032	0.034[b]
Adoption of number of SAPs	-0.004	0.007	0.539	-0.006	0.010	0.544	0.004	0.006	0.554	0.006	0.010	0.537
Location variables (15 district dummies)	Yes			Yes			Yes			Yes		
Number of plot (household) observations												
Overall model significance statistics												
Wald chi2	246.19[a]											
Pseudo R2	0.560											
Log pseudolikelihood	-96.658											

Note: a, b, and c implies significance level at 1, 5, and 10% respectively.

Table 6a. Gendered food (in)security gap: Levels and returns effects(:MHHs vs. *de jure* FHHs)

	Chronic food insecurity			Transitory food insecurity			Food Breakeven			Food surplus		
	MHHs	de jure FHHs	Returns effect	MHHs	de jure FHHs	Returns effect	MHHs	de jure FHHs	Returns effect	MHHs	de jure FHHs	Returns effect
MHHs	a) 0.060	a) 0.103	-0.044***	a) 0.337	c) 0.391	-0.055***	a) 0.355	a) 0.299	0.056***	a) 0.248	c) 0.206	0.042***
FHHs	d) 0.093	b) 0.118	-0.025***	d) 0.394	b) 0.445	-0.051**	d) 0.333	b) 0.277	0.056***	d) 0.180	b) 0.160	0.020***
Levels effect	-0.033***	-0.015**		-0.057***	-0.053***		0.022***	0.022***		0.068***	0.046***	

Note: *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively.

Table 6b. Gendered food (in)security gap: Levels and returns effects (MHHs vs. *de facto* FHHs)

	Chronic food insecurity			Transitory food insecurity			Food Breakeven			Food surplus		
	MHHs	de facto FHHs	Returns effect	MHHs	de facto FHHs	Returns effect	MHHs	de facto FHHs	Returns effect	MHHs	de facto FHHs	Returns effect
MHHs	a) 0.060	c) 0.105	-0.046***	a) 0.337	c) 0.374	-0.037***	a) 0.355	c) 0.211	0.144***	a) 0.248	c) 0.310	-0.062***
FHHs	d) 0.102	b) 0.073	0.028*	b) 0.427	b) 0.495	-0.068**	d) 0.320	b) 0.315	0.005	d) 0.151	b) 0.117	0.034*
Levels effect	-0.042***	0.032*		-0.090***	-0.121***		0.035***	0.104***		0.097***	0.194***	

Note: *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively.

Table 6c. Gendered food (in)security gap: Levels and returns effects(-MHHs vs. All FHHs)

	Chronic food insecurity			Transitory food insecurity			Food Breakeven			Food surplus		
	MHHs	All FHHs	Returns effect	MHHs	All FHHs	Returns effect	MHHs	All FHHs	Returns effect	MHHs	All FHHs	Returns effect
MHHs	a) 0.060	c) 0.080	-0.020***	a) 0.337	a) 0.405	a) -0.068***	c) 0.355	0.312	0.044***	a) 0.248	c) 0.203	0.045***
FHHs	d) 0.095	b) 0.109	-0.014***	d) 0.401	b) 0.453	d) -0.051***	b) 0.330	0.289	0.041***	d) 0.173	b) 0.149	0.024***
Levels effect	-0.035***	-0.029***		-0.064***	-0.047***		0.025***	0.023***		0.074***	0.054***	

Note:; *, ** and *** indicate statistical significance at 10%, 5% and 1% level, respectively.