Small-scale Subsistence Farming, Food Security, Climate Change and Adaptation in South Africa: Male-Female Headed Households and Urban-Rural Nexus

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Abstract

This study examines the role of gender of the head of household on the food security of small-scale subsistence farmers in urban and rural areas of South Africa, using the exogenous switching treatment-effects regression framework. Our results show that agriculture contributes to food security of female-headed more than male-headed households, especially in rural areas. We also observe that male-headed households are more food secure compared to female-headed households, and this is mainly driven by differences in off-farm labour participation. We further observe that the food security gap between male- and female-headed households is wider in rural than in urban areas, where rural male- and female-headed households are more likely to report chronic food insecurity, i.e., are more likely to experience hunger than their urban counterparts. Our results suggest that the current policy interest in promoting rural and urban agriculture is likely to increase food security in both male- and female-headed household, and reduce the gender gap.

Key words: Food security, male-headed household, female-headed households, urban, rural

JEL: Q18, Q54

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1 Introduction

South Africa's strategic plan on the "alignment of investment in agriculture[1]" (RSA, 2014.p.31) mirrors the global strategies of policy makers. Currently, although South Africa has the second largest economy in Africa with and an adequate food supply at the national level, this however has not translated into food security at the household level (Shisana et al., 2014). The recent statistics show that 45.6% of South Africans are food secure, 28.3% are at risk of hunger, while 26% are food insecure, i.e., experience hunger (Shisana et al., 2014). It is suggested that the vulnerability to food insecurity is likely to be more pronounced in female-headed and rural South African households, in comparison to the male-headed and urban households (DOA, 2002). For example, one third of South African households are headed by women, and by 1996, only 52% of them spent a mere R1000 per month on food, compared to 35% of male-headed households who spent the same amount. Further, while 25% of male-headed households spent R3500 per month, only 8% of female-headed households could afford to pay this amount on food (DOA, 2002). In another example, Shisana et al., (2014) shows how urban informal (32.4%) and rural formal (32.8%) South Africans are more food insecure compared to those in urban formal areas (19.0%).

In the endeavour to increase food security and meet the Millennium Development Goals (MDGs), South Africa's programmes and interventions are strongly foregrounded in agriculture (RSA, 2014), like elsewhere around the globe (FAO, 2014). In South Africa an estimated 20.7% of the households engage in agriculture, and 65% of these households use agriculture purely as a subsistence strategy to meet household food demand (RSA, 2014). With the arrival of climate change, however, the strategy of using small-scale subsistence farming to promote food security continues to look bleak. In general, food security[2], or the lack thereof, is by nature multifaceted and multidimensional and although it remains a significant concern in the policymaking arena, it is increasingly being recognised that more information is needed to guide decision makers (Nelson et al., 2011). The same has been noted in South Africa (RSA, 2014).

Relatively recent , FAO noted that: "In all developing regions, female-headed rural households are among the poorest of the poor... There is still limited understanding and few research results concerning the intersection of climate change, gender and agricultural development" (Nelson et al., 2011: p.1). FAO further stated that "Poverty and food insecurity have been considered for decades to be rural problems. Some analyses have shown however that urban poverty is not only growing but has tended to be underestimated in the past ... In urban settings, lack of income translates more directly into lack of food than in rural settings. In all regions, urban and per-urban agriculture is an

[1] This is from the National Policy on Food and Nutrition Security for the Republic of South Africa gazetted on the 22 August, 2014.

[2] Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (FAO, 2008: p.3).

activity in which the poor are disproportionately represented" (Hoornweg and Munro-Faure, 2008: p.10). With increasing concerns about the poor levels of food security, the dependence on agriculture to improve these poor levels and the detrimental effects of climate change on agriculture productivity, areas that had, somewhat, remained dormant have found their way back into the literature with deep and growing interest. The prime examples include: male-female[3] and urban-rural[4] small-scale agriculture. Documenting the current male-female and urban-rural evidence is important from a policy perspective since gender-inequalities, rural development and urban planning are at the heart of policy concerns of most countries in the developing region.

In this study we explore the following: first, the role of agriculture in food security of male- and female-headed households in urban and rural areas. Second, the differences in the determinants of food security between male- and female-headed farm households. Third, we explore the impact of gender of the head of household and geographical location on food security. Our study builds on the existing literature (see, e.g., Levin et al., 1999; Horrell and Krishnan, 2007; Mallick and Rafi 2010; Owusu et al., 2011; Crush et al., 2011; Mkwambisi, et al., 2011; Ibnouf, 2011; Modirwa, and Oladele 2012) and extends the more recent studies by Kassie et al., (2014) and Tibesigwa et al., (2015). The recent two studies investigated the role of gender on food security in rural areas of Kenya and South Africa. In our study we consolidate past studies and compare male-female and urban-rural agriculture. In our investigation we use the 2008 nationwide National Income Dynamics Study (NIDS) and exogenous switching treatment-effects regression (ESTER) framework (see Kassie et al., 2014) to tease out the gender differences in food security of rural and urban small-scale farmers in South Africa. To capture food security we use a subjective and objective measure. The former is the self-reported perception of household food supply, where household food security takes the value of one and zero for food insecurity, while the objective measure is per capita household monthly food consumption.

Overall our analysis yields interesting results. First, similar to Kassie et al., (2014) and Tibesigwa et al., (2015) we find that male-headed households are more food secure than female-headed households. This finding is consistent under objective and subjective measure. Second, extending the study of Kassie et al., (2014) and Tibesigwa et al., (2015), we observe that although male-headed household are more food secure in both rural and urban areas, the gender differences are more pronounced in rural than in urban areas. Third, and extending the current studies we observe that the contribution of agriculture to food security is higher in female-headed households, especially those in rural areas. Fourth, and further extending the current studies, we find that male- and female-headed households in rural areas are more likely to report chronic food insecurity than those in urban areas, where chronic food insecurity refers to

[3]Literature on gender and agriculture go back to as early as the 1970s, most notably in gender and development research (Carr, 2008).

[4]The promotion of agriculture, including urban agriculture was promoted by the UN as early as the 1980s, see Smit et al., (1996).

having less than adequate food, i.e., experience of hunger. This is in contrast to urban households who report break-even, i.e., household food was just adequate and hence at risk of experiencing hunger, and surplus food, i.e., household food was more than adequate and therefore food secure. Fifth, the climate and soil characteristics, especially precipitation, are more significant in predicting food security in rural than in urban areas. Also, winter climate appears to have a uniform impact on food security in both male- and female-headed household, while summer climate is more significant in predicting food security of female-headed households. The rest of the paper is structured as follows: section 2 summaries literature on food security, agriculture of male and female farmers in urban and rural areas, section 3 describes the estimation strategy, section 4 provides the empirical results and section 5 discusses our conclusion.

2 Food security and the participation of male and female farmers in urban and rural agriculture

Fifteen years into the MDGs and Africa still remains overwhelmed by food insecurity. A recent FAO report on The State of Food Insecurity in the World, states that: "A stock-taking of where we stand on reducing hunger and malnutrition shows that progress in hunger reduction at the global level has continued but that food insecurity is still a challenge to be conquered" (FAO, 2014: p.4). The report goes on further to state that: "In Africa, there has been insufficient progress towards international hunger targets, especially in the sub-Saharan region, where more than one in four people remain undernourished – the highest prevalence of any region in the world" (FAO, 2014: p.9). In yet another FAO report on Growing Greener Cities in Africa report, it is noted that: "The challenge of achieving a zero hunger world – in which everyone is adequately nourished and all food systems are resilient – is as urgent in African cities as it is in rural areas" (Thomas, 2012: p.5). The consensus is that, food security, or the lack thereof, is both a rural and an urban problem. Agriculture, and more specific, urban (Rogerson, 2003; Zezza and Tasciotti 2010; Thomas, 2012) and rural agriculture (FAO, 2014) appear to be one of the solutions to this stubborn problem, especially if practiced by poor households[5].

However, agriculture will not have similar effects on rural and urban households' food security owing to the distinctive features between the two areas. For instance, there are substantial variations in economic opportunities; population density; access to financial markets; tenure security; and access to water between urban and rural areas, which are likely to affect agriculture productiv-

[5]UNDP (1996) report notes the following on urban agriculture: 'For the poorest of the poor, it provides good access to food. For the stable poor, it provides a source of income and good quality food at low cost. For middle-income families, it offers the possibility of savings and a return on their investment in urban property, for small and large entrepreneurs, it is profitable business" (Smit et al., 1996: p.4).

ity in different ways[6]. Even gender roles differ between rural and urban areas (Oberhauser et al., 2004). Hence, further complicating the urban-rural agriculture productivity differential, is the unequal position of men and women in the society (Horvoka, 2005; Crush et al., 2011). For instance, female-headed households are generally more vulnerable to food insecurity than male-headed households (Babatunde et al., 2008; Mallick and Rafi 2010; Kassie et al., 2014). This is also evident amongst subsistence farming households (Babatunde et al., 2008; Tibesigwa et al., 2015). For this reason, the role of agriculture to enhance food security is, in the simplest terms, multidimensional and multifaceted. To be effective, therefore, policies need to be designed with these widespread geographical diversity and gendered differentials in mind. But first, this requires an in-depth understanding of the linkages between agriculture and food security in male and female farmers in urban and rural areas. In this study, we set out to unveil these linkages.

As previously alluded, on its own, i.e., without gender, there are large variations in the contribution of urban and rural agriculture to household livelihood and food security. However, while food security and rural agriculture has received attention in the research and policy arena over the years, urban agriculture, in contrast, has been a relatively neglected area (Rogerson, 2003; Hovorka 2006). Recently, however, there has been a resurgent of interest[7] (Rogerson, 2003; Battersby, 2012), fuelled by rapid urbanisation, food insecurity and the inter-related high poverty levels[8] (UNDP, 1996; Battersby, 2012). Further, although urban agriculture is described as a survival strategy (De Zeeuw et al., 2000: Mougeot, 2005), especially amongst the poor who reside in urban areas of developing countries (De Zeeuw et al., 2000; Deelstra and Girardet 2000; Thornton, 2008), it is noted that the contribution of urban agriculture to food security is, however, still unclear (Armar-Klemesu and Maxwell 2000; Frayne 2005; Thornton and Nel, 2007), and lacks scientific evidence (Thornton, 2008). Currently, most of the literature is based on qualitative methods and few quantitative assessments (Thornton, 2008).

Concerning rural agriculture, this is, perhaps, relatively well understood and

[6] Other noteworthy features include food prices, which are higher in urban than in rural areas (Drechsel et al., 2007; Armar-Klemesu 2000). Newland (1980) compared prices of food in five developing countries and found urban prices to be 10-30% more than rural prices (Newland 1980 cited in Armar-Klemesu 2000). As a consequence, the urban poor spend more than two thirds of their income on food and remain the most vulnerable to food price fluctuations (Battersby, 2012; Thomas 2012).

[7] Interest in urban agriculture is not new. Since the late 1970s (May and Rogerson, 1995) to early 1980s (Smit et al., 1996) studies have linked urban agriculture to food security, where it was recognised that agriculture could contribute significantly towards urban hunger. See for example Sanyal, (1987); Freeman, (1991); and Atkinson, (1994). However, the interest in urban agriculture today various from that of the 1980s: First, migration and rapid urbanisation, recent estimates show that approximately one in every four of the poor in developing regions reside in urban areas. This population is amongst those most heavily reliant on urban agriculture (Hoornweg and Munro-Faure 2008). Second, climate change which will not only affect agriculture productivity, but it will increase rural urban migration (Thomas, 2012).

[8] A study by Ravallion et al., (2007) places one-quarter of the poor in developing countries in urban areas. Further, it is stated that the most notable feature of urban poverty is the existence of slums, which are homes to 52% of Africa's urban population (Thomas, 2012).

recently, the scientific evidence on its contribution to food security is well documented. This could be because most of the rural Africans engage in agriculture. For example, in Madagascar, 73% of the rural population engage in subsistence farming. The rural area of Malawi is home to 84% of the country's population, where the rural inhabitants access an average of only 0.23 hectares of arable land (FAO, 2014). Added to this, a comparison of urban and rural agriculture and food security is limited (Walsh and van Rooyen 2015), let alone the gendered urban-rural differences. That is, according to our review of literature, there are no quantitative studies that have considered the urban-rural and male-female nexus. Hence in outlining past studies, the review that follows is a compilation of isolated literature in these areas, where we attempt to consolidate and provide the current state of the nexus.

Hence staying with agriculture, but introducing gender, we outline the gendered differences between urban and rural agriculture. To begin, it is noteworthy to mention that urban (Crush et al., 2011) and rural subsistence agriculture is dominant by women (Smit and Nasr, 1992), who remain socio-economic disadvantaged in both areas (Hovorka 2006). For instance, in Nairobi, Kenya 64.2% of urban farmers are women (Freeman 1991 cited in Slater, 2001) and 55% of urban farmers in Harare, Zimbabwe are women (Mbiba 1995 cited Slater, 2001). In Yaounde, Camerron; Brazzaville in the Republic of the Congo; Bissau in Guinea-Bissau; Lusaka, Zambia and Bangui in Central Africa republic, most of the urban farmers are women as well (Thomas, 2012), who participate in farming due to their poor socio-economic background (Thomas, 2012). Also noteworthy is the fact that the participation of women in agriculture is likely to be higher amongst those who head households (Crush et al., 2011; Thomas, 2012). See Tibesigwa et al., (2015) for further discussions on gender of the head of household and food security.

Land used for subsistence farming differs widely between rural and urban areas. Whereas in urban areas the dependence is on public and private land e.g., residential plots and backyards; roadsides; rooftops; land along the river; or open grounds (Mougeot, 2006; Drechsel and Dongus 2010), including informal and illegal land e.g., vacant land not suitable for housing (De Bon et al., 2010), famers in rural areas use traditionally accessed land (De Bon et al., 2010). It is stated that access to land is one of the main obstacles of urban agriculture (Rogerson, 2003; Horvoka, 2005), affecting female more than male farmers (May and Rogerson 1995; Jacobi et al., 2000; Crush et al., 2011). Since rural areas is characterised by communal and traditional land, the main issue here is tenure security (Kameri-Mbote 2006) which has been shown to affect agriculture productivity. Women who head households are more likely to be disadvantaged in terms of land security (Crush et al., 2012). For example, Hasna (1998) found that ownership of land in rural Ghana limited or prevented women from participating in agriculture. See also Hovorka (2006) for a similar observation in Botswana. Also, in Kenya, women have access to land but not ownership of land (Kameri-Mbote 2006), they are often mere guardians of family land (Heyer 2006). Women in urban areas are more likely to have access to land compared to women in rural areas. This is because unlike in rural areas, where ownership of communal land is driven by culture, urban farming occurs in open space or on land owned by government.

Further, while women urban dwellers often produce on a micro-scale, men predominate in larger farms s (Jacobi et al., 2000), as observed in Dakar, Sudan and Dare salaam, Tanzania (Horvoka, 2005); the same has been noted about Lilongwe and Blantyre in Malawi (Mkwambisi et al., 2011); and Lagos, Nigeria (Thomas, 2012). A plausible explanation can be found in the literature on gender and development. That is, dating back to as early as the 1980s (Carr, 2008), gender and development research has shown how women bear multiple burdens inside (i.e., family responsibilities) and outside (i.e., work responsibilities) the household. Because women have the extra burden of caring for the household members, they are likely to limit their farm participation (Danso et al., 2004; Crush et al., 2011). This is likely to be more pronounced in female-headed households (Crush et al., 2011), owing to the fact that women who head households are more likely to have more responsibilities compared to those who do not.

In addition, rural farming is likely to be a more permanent livelihood strategy, this is in contrast to urban areas where agriculture is likely to be a partial or temporary livelihood (De Bon et al., 2010), producing another distinction between rural and urban agriculture. Added to this, rural agriculture is mainly for self-consumption, and little is supplied to either rural or urban markets. This is likely to be the opposite in urban areas where agriculture output is supplied to urban markets and little is kept for self-consumption (De Bon et al., 2010). For example, in Rwanda, rural farmers consume 80% of their produce, while in Kigali, urban farmers sold 40% of their produce to local markets (Thomas, 2012). Added to the rural-urban difference is the fact that women farmers are more likely to grow subsistence crops for household consumption, while men are more likely to cultivate cash crops (Danso et al., 2004; Heyer 2006). This is observed in Lagos, Nigeria, where the majority of women urban farmers use agriculture to produce food for the household (Thomas, 2012); and in Kenya where bananas (i.e., food crops) are considered to be 'women crops' while coffee (i.e., cash crops) are 'men crops' (Heyer 2006).

Another noteworthy difference is with regards to farm inputs, i.e., urban farmers are likely to have more access to inputs than rural farmers, due to close proximity to the market (De Bon et al., 2010). As it was observed in Tunisia, where urban farmers had easier access to market information and inputs (Thomas, 2012), this pattern is likely to be observed in male farmers than women who have lower incomes (Horvoka, 2005). Another important farm input is water, which is more likely to be a challenge for urban farming than for rural areas (Rogerson, 2003). This could be attributed by the fact that rural agriculture is mainly rain-fed. For example, rice farming in rural Ghana is rain-fed (Drechsel et al., 2007). However, this will increasingly become a disadvantage for rural farming due to the on-going climate change. Access to water is also linked to food safety risks. That is, participation in urban farming is likely to be characterised by risk from polluted environment (e.g., industry pollution) and inputs (e.g., waste water), this risk is likely to be lower in rural areas (De

Bon et al., 2010), as the dependence is more on the natural environment, e.g., rain. For instance, because of untreated waste water and poor soils, in Yaounde, Nairobi and Dakar cities, urban vegetables appear to be inferior to those produced in rural areas (Thomas, 2012). Access to formal and informal credit is another important input that is more present in male farmers and male-headed households, than female-headed households (Kameri-Mbote, 2006), and this is likely to be correlated to socio-economic positioning.

Revisiting climate change, it is stated that Africa a victim of climate change (Thomas, 2012) will experience the effects more than any other continent. This will not only affect agriculture productivity in urban and rural areas, it will also accelerate migration from rural to urban areas, further increasing urban poverty (Thomas, 2012). Because rural agriculture is rain-fed, climate change effects are likely to be more pronounced in rural than in urban areas, and thus producing another distinction between rural and urban agriculture. The Malawian agriculture, which is mainly subsistence in nature for example, is mostly rain-fed, and hence prone to climate change (FAO, 2014). The same can be said about rice farming in Ghana, in that, it is also rain-fed (Drechsel et al., 2007). Lastly, rural bias policies, i.e., rural agriculture is usually a priority for policy makers, while urban public policies are more ambiguous on agriculture and favour the development of other urban activities (De Bon et al., 2010). For example, in Botswana, government policies favoured subsistence rural agriculture until a decade ago (Hovorka 2006). Similarly, in Chad and Cot d'Ivoire, rural farmers enjoy the national agricultural extensions service which is geared towards rural but not urban agriculture (Thomas, 2012). In yet another example, rural agriculture in South Africa is more visible in research and policy arena, although urban agriculture has been supported by the government since the 1990s[9].

So far, and according to our review of literature, most studies on food security are isolated, concentrating on either rural agriculture alone (e.g., Maxwell et al., 1998; Tibesigwa et al., 2014b) or urban agriculture (e.g., Zezza and Tasciotti 2010; Lynch et al., 2013), or male and female famers in rural areas (e.g., Kassie et al., 2014; Tibesigwa et al., 2015) or gender and urban farming (e.g., Slater, 2001). Hence in this study we consolidate these studies by assessing the urban-rural and male-female nexus. For instance, Maxwell et al., (1998) demonstrated the importance of urban agriculture to nutritional status of children in Kampala, Uganda. In contrast, Slater, (2001) found a limited contribution of urban agriculture to income generation in Cape Town, South Africa. They however discovered that the participation in backyard farming empowered women of low income-households and improved their social networks. In Gaborone, Botswana, Horvoka's (2005) study revealed that gender influenced the type and quantity produced from urban farming. In another study consisting of 11 Southern Africa Development Community (SADC) countries, Crush et al., (2011) made a similar observation to Slater, (2001), i.e., they found that urban agriculture was not a significant contributor of household food, and that households mainly depended

[9] See the 1995 White paper on Agriculture; the 1998 White paper on National Water Policy for South Africa; and the 2001 paper on Spatial Policy and Land Use Management.

on supermarkets and the informal sector. On a slight departure, Babatunde et al., (2008) assessed the determinants of food security in male- and female-headed households in rural Nigeria and found that female-headed households were more insecure and that male-headed household had higher crop output and income. Amongst households in Bangladesh, Mallick and Rafi (2010) did not observe any significant difference in food security between male and female-headed households, contrasting Babatunde et al., (2008).

Further showing the gendered differences in agriculture, in Lilongwe and Blantyre cities of Malawi, Mkwambisi et al., (2011) observed that male-headed households had lower socio-economic status and used urban farming as insurance against income losses. They further observed that male-headed households were mainly middle- and high-income earners and participated in urban agriculture for personal consumption. Zezza and Tasciotti (2010) provide evidence on the importance of urban agriculture to food security using a sample of 15 developing countries, although this was more evident amongst the urban poor. A recent study by Lynch et al., (2013) revealed that urban and peri-urban agriculture was a vital element for household food security in Sierra Leone. In more recent studies, Kassie et al., (2014) measured the relationship between gender and food security in rural Kenya and found female-headed households to be more vulnerable, while Tibesigwa et al., (2015) used a sample of rural households in South Africa, and found rural agriculture to be significant to food security, especially amongst female headed households. Walsh and van Rooyen (2015) in analysing the determinants of food insecurity in rural and urban areas of Free State, South Africa found that different determinants predicted food insecurity.

3 Empirical Strategy

3.1 *Estimation Model*

In exploring the male-female and urban-rural differences in food security, we adopt the exogenous switching treatment-effects regression (ESTER) framework from Kassie et al., (2014). Using the framework, we first measure the determinants of food security in male- and female-headed farm households. We then proceed to estimate the impact of gender of the head of household on food security.

$$y_1 = \mathbf{X}\beta_1 + u_1 \quad \text{if} \quad G = 1 \tag{1}$$

$$y_2 = \mathbf{X}\beta_2 + u_2 \quad \text{if} \quad G = 2 \tag{2}$$

where y_1 and y_2 represent food security in male- and female-headed household respectively. G is the dummy variable with 1 representing male-headed household, while 2 captures female-headed households, and $\mathbf{X}$ is a vector of household and farm characteristics. The error terms, u_1 and u_2 are normally distributed with zero mean and a covariance matrix (equation 3). Because gender of the head of household is exogenously determined, this implies that

$\sigma_1 = \sigma_2 = 0$, hence the ESTER framework will produce unbiased estimates.

$$\sum = \begin{pmatrix} \sigma_2^1 & \sigma_{12} & \sigma_{1\mu} \\ \sigma_{12} & \sigma_2^2 & \sigma_{2\mu} \\ \sigma_{1\mu} & \sigma_{2\mu} & 1 \end{pmatrix} \tag{3}$$

Note that estimating two separate equations, i.e., (1) and (2), for male- and female-headed households enables us to analyse the differential impact of $\mathbf{X}$ on y_1 and y_2. The assumption of this approach is that $\mathbf{X}$ have different impact, i.e., assumes different slope coefficients for male- and female-headed households. This differs from a pooled regression approach which includes a dummy gender regressor and assumes common slope coefficients for male- and female-headed households (Kassie et al., 2014). To measure the impact of gender on food security we estimate and compare the actual and counterfactual expected food security between male- and female-headed households using the treatment-effects approach and hence the term ESTER:

$$E(y_1|G = 1) = X_1\beta_1 \tag{4}$$

$$E(y_2|G = 2) = X_2\beta_2 \tag{5}$$

$$E(y_2|G = 1) = X_1\beta_2 \tag{6}$$

$$E(y_1|G = 2) = X_2\beta_1 \tag{7}$$

where equation (4) and (5) are the actual expected outcomes, while equation (6) and (7) represent the counterfactual expected outcomes. Equations 4-7 are further defined in Table 1, where, as before, (*i*) and *(ii)* are the actual food security observed in the sample for male- and female-headed household respectively, while *(iii)* and *(iv)* represent the counterfactual food security status.

In Table 1, TT is synonymous to the effect of treatment on the treated, i.e., it denotes the effect of gender on food security of male-headed household if they maintain their own characteristics but had the returns or coefficients of female-headed households (Kassie *et al.*, 2014). This is the difference between *(i)* - *(iii)* in Table 1, i.e.:

$$TT = E(y_2|G = 1) - E(y_2|G = 1) = \mathbf{X}_1(\beta_1 - \beta_2) \tag{8}$$

Similarly, TU is synonymous to the effect of treatment on the untreated, i.e., it measures the effect of gender on the food security of female-headed households if they maintain their characteristics but had the same returns as male-headed households (Kassie *et al.*, 2014). In Table 1 this is the difference between *(iv)* - *(ii)* i.e.:

$$TU = E(y_2|G = 2) - E(y_2|G = 2) = \mathbf{X}_2(\beta_1 - \beta_2) \tag{9}$$

Further, $\mathrm{BH}_1$and BH_2, in Table 1, measure the base heterogeneity for male- and female-headed household respectively, they capture the effect of unobservable characteristics that cause the gender differences in food security (Kassie et al., 2014). These are presented in equation (10) and (11) respectively:

$$BH_1 = E(y_1|G = 1) - E(y_1|G = 2) \tag{10}$$

$$BH_2 = E(y_2|G = 1) - E(y_2|G = 2) \tag{11}$$

Overall, using the above estimation framework we are able to address the objectives of the study, i.e., compare the determinants of food security between male- and female-headed household and measure the impact of gender on food security in rural and urban areas.

3.2 *Data and Variable Description*

The data is from the 2008 National Income Dynamics Study (NIDS) which is managed by the Southern Africa Labour and Development Research Unit (SALDRU) in the University of Cape Town. NIDS is a nationwide survey primarily conducted to collect information on demographics, well-being, human capital and labour force participation from a combination of individual and household level questionnaires. NIDS currently has three waves, the first wave was conducted in 2008, the second in 2010 and the third wave in 2012. For a more complete description of NIDS see SALDRU (2008, 2010, 2012). In the current study we use the 2008 survey and approximately 1100 households who engage in small-scale subsistence farming. For more details on gender differences at household level see Tibesigwa et al., (2015). As previously mentioned, in exploring the gendered food security, we compare between male- and female-headed households. Note that the head of household information is self-reported, i.e., it is derived from those individuals who identified themselves as the head of household. As our outcome, we use two measures of food security so as to compare the robustness of our results to different definition of food security. The first outcome is subjective in nature and is derived from self-reported perception of households' food condition. Specifically, households were asked the following question: "Concerning your household's food consumption over the past month which of the following is true? It was less than adequate for your household's needs? It was just adequate for your household's needs? It was more than adequate for your household's needs?"

The subjective food security measure is binary and takes the value of one if the household's food was either adequate or more than adequate and zero otherwise. See Mallick and Rafi (2010); Kassie et al., (2014) and Tibesigwa et al., (2015) for a full description of subjective measures of food security. In addition, we augment the subjective measure with a second outcome, this is an objective measure defined as per capita household consumption using monetary values (see Iram and Butt 2004; Feleke et al., 2005; Di Falco et al., 2011; Tibesigwa et al., 2015). This includes household food consumption of purchased food, produced food from farming, food given as gift and food given as payment. This is then divided by the number of household members. A set of regressors are used as determinants of food security following earlier studies on food security. These include age, education, gender and marital status of the head of household. In addition, we include household and farm characteristics which include household size, number of household assets, off-farm household income and whether the household is located in rural or urban areas. We also include farm extensions, soil characteristics, district level mean precipitation and temperature. For a detailed description of the climate and soil variables see Tibesigwa et al., (2014a).

4 Empirical Results

4.1 *The Contribution of Agriculture to Households' Food Security*

In this section we compare the contribution of agriculture to household food security in male- and female-headed households in urban and rural areas. We begin by showing (1) the amount of the agriculture output that is consumed by the household, (2) output that is given away as gift and (3) the output that is sold by the household. This follows from Tibesigwa et al., (2014a), where, unlike the authors, we compare between male- and female-headed households in urban and rural areas. Table 2 shows the distribution of agricultural output, Panel A depicts the pooled sample, Panel B displays rural households and the urban households are shown in Panel C.

We find that in the pooled sample (column 1), most of the crops that were harvested were kept for household consumption (57.8%), while the remaining small portion of the output was either sold (30.1%) or given away as gifts (12.0%). This is in sharp contrast to livestock output which is displayed in the lower part of column 1 and where we observe that the majority of the livestock was sold (48.9%), a little was either consumed (26.7%) or given away as gift (24.3%). This confirms the subsistence nature of the agriculture amongst these households, in that most of agriculture output is kept for consumption (Tibesigwa et al., 2014a). Column 2 and 3 compares between male- and female-headed households, we find that while male-headed households kept only 44.7% of crop output for consumption, female-headed households kept 71.7% of the agriculture output. This is consistence with the current literature that has stated that while women grow consumption crops, men often grow cash crops. We further observe in column 2 and 3 that the livestock products are mainly sold (56.6%) or consumed (28.0%) by male-headed households, whereas in female-headed households the majority of the livestock products are either given away as gift (40.8%) or sold (34.8%).

When we move to Panel B in Table 2 which compares male- and female-headed households in rural area, we observe that female-headed households in rural area mainly consumed (68.8%) their crop output, while in the male-headed households the output is equally distributed between sales (43.4%) and own consumption (43.5%). This finding echoes the current literature which has stated that in rural areas, female-headed households are more likely to consume their products than male-headed households. In addition, while male-headed households in rural areas sell 65.4% of their livestock products, female-headed households either sell the livestock (29.0%), or consume (28.6%), but the majority of it as given away as gifts (42.5%).

Amongst the urban sample in Panel C, we find that as in rural areas (Panel B), female-headed households consume the majority of their crops (85.3%), and very little is either sold (6.9%) or given away as gift (7.9%). Amongst the male-headed households in urban areas, although the majority of the crops are also kept for consumption (54.3%), this is almost half of the amount that female-headed households keep for consumption. Again this is consistent with literature that notes that in rural areas female-headed households are more likely to consume their produce than male-headed households. As before we find that under livestock products, most of the products are sold in both male-headed (41.1%) and female-headed (45.2%) households.

When we compare between rural (Panel B) and urban (Panel C) households, we find that female-headed households in urban areas keep a higher proportion of their crop output for consumption (85.3%), in comparison to female-headed households who only keep 68.8%. We also observe that male-headed households in urban area keep slightly higher crop output for consumption in comparison (54.3%) to those in rural areas (43.5%). Speculatively one may argue that because of underdeveloped markets in rural areas, rural households are likely to use agriculture as a source of income, in addition to consumption, so as to meet other household requirements, e.g., school fees.

In Table 3 we show the contribution of agriculture to the per capita household consumption. Recall that our objective measure is per capita household consumption (using monetary values) and includes (1) household food consumption of purchased food, (2) produced food from farming, (3) food given as gift and (4) food given as payment. In comparing these different sources of household food, we find that overall most of the food that is consumed by the households is purchased, followed by produced food and little is from gifts and payments. In comparing between male- and female-headed households in rural areas (Panel B), we observe that agriculture contributes more to household food amongst female-headed households (23.3%), than in male-headed households (18.2%). In urban households (Panel C), however, we find that agriculture contributes slightly more in male-headed households (18.7%) than in female-headed households (13.1%). In comparing between rural and urban areas, we find that agriculture contributes more to household food in female-headed households in rural areas (23.3%), than in urban areas (13.1%). Amongst the male-headed households however, the contribution of agriculture to household food is equal between rural (18.2%) and urban areas (18.7%).

4.2 *Food Security in Male- and Female-Headed Farm Households*

Table 4 depicts the descriptive statistics of the sample, disaggregated by gender. Both the subjective and objective measure show a relatively higher food security in male-headed than in female headed households. On average the female heads of household are older than their male counterparts. Further, according to Table 4, we observe little variation in the average household size, income and assets between male- and female-headed households. Table 4 also shows that male-headed households spend more on farm extensions than female-headed households. Also, it appears that on average both male- and female-headed households farm in B1-ferralsols, acrisols, lixisols soils, with approximately 14^oc temperature and 28mm of precipitation in winter; and 20 ^{o}c temperature with 93mm of precipitation in summer.

Table 5 shows the gender-specific differences in the determinants of food security between male- and female-headed household. The *F-tests* under the subjective and objective measures are $F(43,\ 1041) = 2.85$ and $F(43,\ 1041) = 15.66$ respectively suggesting that there is 1% statistically significant interaction between gender and the variables. The results, in Table 5, appear to be qualitatively similar between the subjective and objective measure, i.e., Panel A and B. Recall that the subjective measure is self-reported and takes the value of 1 if the household is food secure and 0 otherwise, while the objective measure is real household consumption per capita. Some of the most notable differences between Panel A and B are household size and education of the head of household being significant in the latter but not in the former.

Overall the results are in line with our expectation and consistent with the current literature. To give an example, relatively similar observation can be found in Kassie et al., (2014). As we observe that the factors that predict food security in male-headed households are mostly significant in predicting food security in female-headed households. In particular, age, household size, household income, number of household assets, marital status, climate variables, crop and livestock extensions are significant in predicting food security in both male-and female-headed households. The main difference is the magnitude, i.e., the size of the coefficient and level of significance. More specifically, household size, and education appear to have a greater effect on the food security of female-headed households, while household off-farm income, household assets and marital status are more significant in predicting food security in male-headed households. This is in agreement with Owusu et al., (2011) who found that off-farm income significantly predicts food security in general, while Levin et al., (1999) and Owusu et al., (2011) found this to be more significant in male-headed households. Similar to Levin et al., (1999) household size is negative and significant in predicting food security. Under the subjective measure, male-headed households located in either urban or formal rural areas are more likely to report food insecurity than those in traditional rural areas, while under the objective measure location does not appear to predict food security. Also, being married increases the likelihood of reporting food security, and this is more significant in male-headed households.

Household's expenditure on farm inputs, specifically, crop farm extensions (i.e., fertilisers, manure, ploughing and seeds) which is significant amongst female-headed households and livestock farm extensions (i.e., livestock feed, dips and veterinary services) significant in male-headed households appear to have a non-linear relationship with food security. This is consistent with Di Falco et al., (2011) who also observed a non-linear relationship between food security and farm extensions. The different types of soils have different impacts on male- and female-headed households, but their effects are more significant in female-headed households. This suggests that female-headed households are likely to cultivate in more fertile land compared to male-headed household. Winter precipitation and temperature predict food security in both male- and female-headed households, while summer precipitation and temperature only predict food security in female-headed households.

Thus far we have compared the determinants of food security between male- and female-headed households. Recall that the second objective of this study is to measure the impact of gender on food security. Here, we address this objective. Table 6 compares the expected food security between actual and counterfactual scenarios for male- and female-headed households. In deriving these scenarios, we use the estimates in Table 5 and as before, Panel A shows the subjective measure, while Panel B depicts the objective measure. In Panel A, (*i*) and (*ii*) show the observed or actual food security for male- and female-headed household respectively. We observe that the probability of food security is statistically significantly higher by 14.6% in male-headed in comparison to female-headed farm households. However, according to (*iii*), if female-headed households had similar response coefficients as male-headed households, the food security gap between male- and female headed household would have been 6.2%. This is 8.4% lower than the actual or observed food security gap. On the other hand, when we look at the counterfactual in *(iv)*, we see that if male-headed households had similar response coefficients as female-headed households the probability of food security would have been higher by only 5.1%.

Similarly, (*i*) and (*ii*) in Panel B presents observed food consumption per capita for male- and female-headed households respectively. According to the observed values, male-headed households have 13.2% statistically significantly higher food consumption per capita in comparison to female-headed households. In the counterfactual case in (*iii*) the food consumption gap between male- and female headed households would have been much lower at 2.5% (0.159). Further, in (*iv*) male-headed households would only have consumed 0.9% (0.064) higher than female-headed households if they had the same characteristics as female-headed households. The statistical significance of the heterogeneity effects in Panel A and B indicates that there are unobserved factors that make male-headed households more food secure than female-headed household. Overall, this suggests that gender of the head of the households, specifically, being male significantly increases household food security. This is influenced by both observed and unobserved characteristics. These findings are qualitatively similar to the studies by Kassie et al., (2014) and Tibesigwa et al., (2015).

Table 7 shows the distribution of male- and female-headed households under chronic, break-even and surplus household food. Chronic food insecurity refers to households who reported having less than adequate food and hence experience hunger, break-even are those who reported that their household food was just adequate and are therefore at risk of hunger, and surplus food refers to those that mentioned that their household food was more than adequate, i.e., food secure (see Kassie et al., 2014). According to Table 7, the majority of female-headed households (53.1%) reported being chronically food insecure, while male-headed households are evenly split between chronic food insecurity (44.12%) and break-even food security (44.9%). In Table 8 we explore the distribution of food security further using the subjective (i.e., chronic food security, break-even and surplus food) and objective (i.e., Q25, Q5 and Q75) categories. Specifically, whereas in Panel A we show the average per capita consumption amongst those who reported chronic food security, break-even and surplus food, in Panel B we use the objective measure quantiles (i.e., Q25, Q5 and Q75).

Upon disaggregating the food security measures in Table 8 we make two observations: first, we find that the average per capita consumption under subjective categories (i.e., chronic food security, break-even and surplus food) is strikingly close to that of the objective categories (i.e., Q25, Q5 and Q75). More specifically, in both cases, we observe an increase in the average per capita consumption gap between male- and female-headed households as we move from column 1 to 3 (i.e., chronic food security, break-even and surplus food in subjective categories) and column 4 to 6 (i.e., Q25, Q5 and Q75in objective categories). That is, the gender gap increases with increases in the availability of household food, and this observation is consistent under the subjective and objective measure. Second, the average per capita consumption in column 3under the subjective measure (i.e., chronic food insecurity in Panel A) is slightly less than the average per capita consumption in column 6 under the objective measure (i.e., quantile Q25 in column 4 in Panel B). However, the average per capita consumption is slightly more in the subjective than under the objective measure when we compare between chronic food insecurity (column 1) and Q55 (column 4), and break-even (column 2) and Q5 (column 5). In Table 9 and 10 we use the disaggregation of subjective and objective measures to derive the actual and counterfactual food security scenarios under the treatment-effects framework. Similar to Kassie et al., (2014) we observe that female-headed households have a higher probability of experiencing chronic food security, while the male-headed households have a higher probability of reporting food surplus.

4.3 *Food Security in Male- and Female-Headed Farm Households in Urban and Rural Areas*

To gain a further understanding of gender dynamics, here, we compare between rural and urban areas. In essence this section extends the most recent work by Kassie et al., (2014) and Tibesigwa et al., (2015). Table 11 mimics Table 5 by showing the determinants of food security, the only difference is that here we compare between rural and urban areas. In particular, Panel A shows the results using subjective and objective measure amongst the rural sample, while Panel B shows the results from the urban sample. The main differences between the rural and urban area is the magnitude, i.e., the size of the coefficients and level of significance. Specifically, in rural areas, household size, education, marital status are more significant in female-headed households, while household income and expenditure on livestock extension in male-headed households. Also, the effects of soil characteristics on food security appear to be similar for male- and female-headed households in rural areas. This is in slight contrast to urban areas where we observe household size and household off-farm income, household assets and marital status in male-headed households. Further, the climate and soil variables, especially precipitation, are more significant in predicting food security in rural than in urban areas.

In Table 12 and 13 we show the effects of gender on food security in rural and urban areas. When we compare food security using the subjective measure, i.e., Panel A in Table 12 and Table 13 we see that the observed probability of food security is 9.1% in rural areas and 6.1% in urban areas. A similar pattern is observed under objective measure, i.e., Panel B in Table 12 and 13 depicts a statistically significant 1.7% per capita food consumption gap in rural areas, while in the urban areas this gap is -0.5%, although it is not statistically significant. Thus the observed or actual values under subjective and objective measure reveal that male-headed households are more food secure. Further, we observe higher food security gap between male- and female-headed households in rural than in urban areas. However, if female-headed households had similar characteristics as male-headed households, the food security gap would have reduced to 7.0% and 1.6% in rural and urban areas respectively. This can be observed in *(iii)* in Panel A in Table 12 and 13. Added to this, while this gap is significant at 1% level in rural areas it is however insignificant in urban areas.

Under the objective measure in Panel B in Table 12 and 13, the counterfactual in *(iii)* shows that if female-headed households had the same characteristics as male-headed households, the per capita consumption gap would have been 1.7% and 1.2% in rural and urban areas respectively. However this remains insignificant in urban areas, while in rural areas it is significant at 1% level. Under the counterfactual in *(iv)*, Panel A in Table 12 and 13 show a 8.4% food security gap in rural areas and 6.7% in urban areas if male-headed households had similar characteristics as female-headed households. Similar pattern emerges in Panel B where we find a 2.4% and -1.4% in rural and urban respectively. Hence overall, there is a higher food security gap in rural than in urban areas, and this can be explained by both observed and unobserved characteristics, as evident in the significant heterogeneity effects. Table 14 uses the subjective measure and compares the distribution of male- and female-headed households under chronic (i.e., experiencing hunger), break-even (i.e., at risk of experiencing hunger) and surplus household food (i.e., food secure) between rural and urban areas. We find that more female-headed households in rural areas reported chronic food security (54.5%), than the female-headed households in urban areas (47%). Similarly, more male-headed households reported chronic food security in rural areas (45.6%), than in urban areas (40.4%). Under the objective measure, table 15 compares the average per capita consumption between rural and urban areas, and we observe that households located in urban areas have higher per capita consumption than those located to rural areas.

5 Conclusion

This study set out to explore the effects of gender of the head of household on food security of small-scale farm households in rural and urban areas. We employ Kassie et al., (2014) exogenous switching treatment-effects regression (ESTER) framework, to tease out the gender and geographical effects, on a sample of 1100 farm households from the 2008 nationwide National Income Dynamics Study (NIDS). The following summarises our results: Off-farm household income and number of household assets are the main determinant of household food security. While number of household assets appears to have an almost equal impact on food security of male- and female-headed household, off-farm income however is more significant in predicting food security of male-headed households. The other factors that influence food security include marital status, purchase of farm inputs i.e., farm extensions and education. In addition, winter climate appears to have a uniform impact on food security in both male- and female-headed household, while summer climate is more significant in predicting food security of female-headed households. The effects of climatic characteristics on food security are more apparent in rural than in urban areas.

We observe that the contribution of agriculture to food security is higher in female- than in male-headed households, especially those in rural areas. We further find that the gender of the head of household determines the level of food security. More specific, male-headed small-scale farm households are more food secure than female-headed households, and this finding is consistent under subjective and objective measures of food security. Since off-farm income is one of the main determinants of food security in male-headed households, promoting off-farm labour activities to female-headed households will likely boost their food security and narrow the gender gap. In addition, the food security gap between male- and female-headed households is higher in rural areas than in urban areas, where households in rural areas are more likely to report chronic food insecurity than those in urban areas, where chronic food insecurity refers to having less than adequate food, i.e., experience of hunger. In contrast, urban households are more likely to report break-even, i.e., household food was just adequate and hence at risk of experiencing hunger, and surplus food, i.e., household food was more than adequate and therefore food secure.

Overall, our results support the growing interest of the South Africa government, and policy makers, in general in promoting rural agriculture and development. This is because, it appear that agriculture contributes more to food security in rural than in urban areas, and this is more pronounced amongst female-headed households. Also, while urban small-scale farm households have more opportunities, e.g., off-farm employment, rural areas are often resource poor and characterised by under-developed markets, thus offering limited opportunities for small-scale farm households. However because agriculture also contributes to household food security in urban areas, the current polices on urban agriculture should continue to be emphasised, in light of the climate change effects on agriculture productivity and rural-urban migration.

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Table 1: Conditional expectations, treatment and heterogeneity effects

	Male-headed households	Female-headed households	Treatment effects
Male-headed households	*(i)* $E(y_1 \mid G = 1)$	*(iii)* $E(y_2 \mid G = 1)$	TT = *(i)* - *(iii)*
Female-headed households	*(iv)* $E(y_1 \mid G = 2)$	*(ii)* $E(y_2 \mid G = 2)$	TU = *(iv)* -*(ii)*
Heterogeneity effects	BH_1 = *(i)* - *(iv)*	BH_2 = *(iii)* - *(ii)*	

Table 2: % Distribution of Agriculture Revenue

	Panel A: All			Panel B: Rural			Panel C: Urban		
	Pool	Male-headed households	Female-headed households	Pool	Male-headed households	Female-headed households	Pool	Male-headed households	Female-headed households
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Crops (%)									
• Sold	30.1	42.9	16.7	32.0	43.4	18.8	19.0	38.3	6.9
• Given away as gift	12.0	12.5	11.6	12.7	13.1	12.3	7.7	7.4	7.9
• Retained for consumption	57.8	44.7	71.7	55.3	43.5	68.8	73.3	54.3	85.3
Livestock (%)									
• Sold	48.9	56.6	34.8	52.5	65.4	29.0	42.5	41.1	45.2
• Given away as gift	24.3	15.4	40.8	19.5	6.9	42.5	32.9	30.3	37.7
• Retained for consumption	26.7	28.0	24.5	28.0	27.6	28.6	24.6	28.6	17.1

Table 3: % Distribution of Food Sources

	Panel A: All			Panel B: Rural			Panel C: Urban		
	Pool	Male-headed households	Female-headed households	Pool	Male-headed households	Female-headed households	Pool	Male-headed households	Female-headed households
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Food given as payment	2.2	0.0	4.1	0.0	0.0	0.0	7.5	0.1	16.1
Food given as gift	0.4	0.4	0.3	0.4	0.3	0.5	0.3	0.6	0.0
Produced food	19.7	18.4	20.7	21.2	18.2	23.3	16.1	18.7	13.1
Purchased food	77.7	81.2	74.9	78.4	81.4	76.2	76.0	80.6	70.7

Table 4: Descriptive Statistics

Variable	Male-headed households	Female- headed households	Differences
Food security	0.5584	0.4693	-0.0892***
Per capita household food consumption	206.3726	186.4257	-19.9469*
Age of the head of household	53.9462	56.4774	2.5311***
Household size	5.2523	5.1812	-0.0711
Per capita household off-farm income	754.3321	644.7691	-109.5629
Head of household is employed	0.5438	0.3867	-0.1570***
Number of household assets	5.8609	5.2621	-0.5987***
Education level of head of household	2.0297	1.8366	-0.1931***
Marital status of head of household	0.7106	0.2460	-0.4646***
Urban area	0.2801	0.2039	-0.0763***
Crop extension expenditure	49.8940	39.6065	-10.2875
Livestock extension expenditure	75.9920	54.7155	-21.2765
Type of soil	4.8700	5.0341	0.1641
Temperature, winter	14.2403	14.3789	0.1386**
Temperature, summer	20.3423	20.4660	0.1237**
Precipitation, winter	28.0311	27.8102	-0.2209
Precipitation, summer	93.4674	93.3083	-0.1591
Observations	539	618	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5: Food security – Male vs. Females

	Panel A: Subjective measure Food security (1/0)		**Panel B: Objective measure Per capita household consumption**	
Variables	(1) Male-headed households	(2) Female-headed household	(3) Male-headed households	(4) Female-headed household
Age of the head of household	0.0138**	0.0196***	0.000443***	8.13e-05
	(0.00669)	(0.00568)	(0.000133)	(8.94e-05)
Household size	0.260	0.172	-0.0228***	-0.0333***
	(0.166)	(0.151)	(0.00330)	(0.00239)
Per capita household off-farm income	0.248***	0.166**	0.00825***	0.00655***
	(0.0844)	(0.0804)	(0.00177)	(0.00124)
Number of household assets	0.283***	0.323***	0.00697***	0.00685***
	(0.103)	(0.0949)	(0.00221)	(0.00149)
Education level of head of household	-0.0636	-0.0881	0.00356*	0.00494***
	(0.0874)	(0.0897)	(0.00185)	(0.00141)
Head of household is married	0.356**	0.344**	0.0130***	0.00131
	(0.175)	(0.152)	(0.00364)	(0.00238)
Urban areas	-1.139***	-1.224***	-0.0121	0.00549
	(0.419)	(0.393)	(0.00811)	(0.00625)
Formal rural areas	-0.877***	-0.157	-0.00828	0.00468
	(0.258)	(0.228)	(0.00516)	(0.00358)

	Panel A: Subjective measure Food security (1/0)		Panel B: Objective measure Per capita household consumption	
Variables	(1) Male-headed households	(2) Female-headed household	(3) Male-headed households	(4) Female-headed household
Expenditure on crop extensions	-0.000151	-0.00106	1.81e-05	2.30e-05*
	(0.00115)	(0.000908)	(2.17e-05)	(1.38e-05)
Expenditure on crop extensions^2	8.57e-07	2.10e-07	-9.90e-09	-1.56e-08**
	(1.14e-06)	(5.12e-07)	(1.80e-08)	(7.31e-09)
Expenditure on livestock extensions	0.00180**	-0.000299	7.45e-06	-7.46e-07
	(0.000831)	(0.000604)	(8.25e-06)	(9.14e-06)
Expenditure on livestock extensions^2	-1.02e-06**	2.38e-07	-2.00e-09	3.87e-09
	(4.99e-07)	(3.21e-07)	(1.90e-09)	(4.30e-09)
A4-lixisols, cambisols, luvisols	-0.0184	-0.453	0.00298	-0.00872*
	(0.340)	(0.315)	(0.00723)	(0.00505)
AR-arenosols	-0.904	-0.194	0.0275**	0.0240***
	(0.567)	(0.501)	(0.0120)	(0.00757)
B1-ferralsols, acrisols, lixisols	-1.082	-0.628	-0.00933	-0.0117
	(0.905)	(0.690)	(0.0184)	(0.0106)
C1-luvisols, planosols & solonetz	-0.185	0.592**	0.00344	0.0107**
	(0.280)	(0.266)	(0.00592)	(0.00423)
E1-leptosols, regosols, calcisols	-0.397	-0.189	-0.00311	0.00273
	(0.251)	(0.250)	(0.00522)	(0.00392)
Temperature, winter	1.090	2.046	0.163***	0.0510**
	(1.823)	(1.583)	(0.0365)	(0.0255)
Temperature, winter^2	-0.0670	-0.0689	-0.00632***	-0.00209*
	(0.0769)	(0.0682)	(0.00156)	(0.00110)
Temperature, summer	-12.33*	-1.098	-0.301**	0.105
	(6.941)	(5.913)	(0.142)	(0.0948)
Temperature, summer^2	0.299*	0.0438	0.00707**	-0.00177
	(0.158)	(0.135)	(0.00326)	(0.00215)
Precipitation, winter	-0.0313	0.196	-0.00108	-0.00145
	(0.179)	(0.206)	(0.00366)	(0.00331)
Precipitation, winter^2	-0.00178	-0.000854	-5.91e-05*	-5.37e-05**
	(0.00159)	(0.00164)	(3.36e-05)	(2.60e-05)
Precipitation, summer	-0.0770	0.0765	-0.00550	0.00740**
	(0.257)	(0.228)	(0.00494)	(0.00366)
Precipitation, summer^2	-4.63e-05	0.000293	9.23e-06	2.09e-06
	(0.000315)	(0.000260)	(6.25e-06)	(4.11e-06)
Temperature, summer* Precipitation, summer	0.00516	-0.00543	0.000188	-0.000377**
	(0.0112)	(0.0103)	(0.000220)	(0.000165)
Temperature, winter * Precipitation, winter	0.0124	-0.00970	0.000417	0.000308
	(0.0167)	(0.0192)	(0.000343)	(0.000308)
Constant	115.3*	-15.43	2.086	-1.724*
	(69.72)	(59.82)	(1.414)	(0.963)
Observations	539	618	539	618
R-squared			0.481	0.526

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Reference: traditional rural areas, A2-ferralsols, acrisols & lixisols

Table 6: Food security – Male vs. Females Treatment and Heterogeneity Effects

	Panel A: Subjective measure			Panel B: Objective measure		
	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects
Male-headed households	*(i)*0.5459	*(iii)* 0.4839	0.0619***	*(i)*6.4947	*(iii)* 6.3349	0.1598***
	(0.0094)	(0.0073)	(0.0118)	(0.0198)	(0.0162)	(0.0254)
Female-headed households	*(iv)*0.5095	*(ii)* 0.459	0.0505***	*(iv)*6.5481	*(ii)* 6.4839	0.0642***
	(0.0100)	(0.0083)	(0.0129)	(0.0163)	(0.0148.)	(0.0219)
Heterogeneity effects	0.0363***	0.0249***		-0.0534***	-0.1489***	
	(0.0110)	(0.0079)		(0.0102)	(0.0084)	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 7: % distribution of food security under subjective measure

	Chronic Food Insecurity	Break-even Food	Surplus Food
Male-headed households	44.2	44.9	11.0
Female-headed households	53.1	38.2	8.7

Table 8: Average per capita food consumption using subjective categories (self-reported) and objective categories (quantiles)

	Panel A: Subjective categories			Panel B: Objective categories		
	Chronic Food Insecurity	Break-even Food	Surplus Food	Q25	Q5	Q75
	(1)	(2)	(3)	(4)	(5)	(6)
Male-headed households	174.23	215.60	298.20	131.86	181.73	315.36
Female-headed households	163.94	210.68	216.96	120.31	174.86	282.53

Table 9: Disaggregated Food security – Male vs. Females Treatment and Heterogeneity Effects – Subjective measure

	Chronic Food			Break-even Food			Surplus Food		
	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects
Male-headed households	0.4542	0.5161.	-0.0619***	0.4386	0.4078	0.0307***	0.1072	0.0759	0.0312***
	(0.0094)	(0.0073)	(0.0118)	(0.0088)	(0.0061)	(0.0105)	(0.0066)	(0.0043)	(0.0078)
Female-headed households	0.4905	0.5409	-0.0505***	0.3884	0.3687	0.0197*	0.1211	0.0903	0.0308***
	(0.0100)	(0.0083)	(0.0129)	(0.0076)	(0.0078)	(0.0109)	(0.0053)	(0.0057)	(0.0078)

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 10: Disaggregated Food security – Male vs. Females Treatment and Heterogeneity Effects – Objective measure

	Q25			Q50			Q75		
	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects
Male-headed households	6.1918	7.7327	-1.5409***	6.5007	6.4717	0.0290	6.8187	7.1539	-0.3352***
	(0.0195)	(0.0396)	(0.0421)	(0.0171)	(0.0032)	(0.0234)	(0.0208)	(0.0243)	(0.0412)
Female-headed households	5.9568	6.2109	-0.2541***	6.5115	6.4990	0.0124	7.1443	6.7461	0.3982***
	(0.0243)	(0.0156)	(0.0336)	(0.0115)	(0.0144)	(0.0242)	(0.0165)	(0.0149)	(0.0303)

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 11: Food security – Male vs. Females in Urban and Rural Areas

	Panel A: Rural Area				Panel B: Urban Area			
	Subjective measure Food security (1/0)		Objective measure Per capita household consumption		Subjective measure Food security (1/0)		Objective measure Per capita household consumption	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Female-headed household	Male-headed households	Female-headed household	Male-headed households	Female-headed household	Male-headed households	Female-headed household	Male-headed households
Age of the head of household	0.0129	0.0259***	0.000101	-5.83e-05	0.0205	0.0146	0.000821**	0.000492*
	(0.00842)	(0.00736)	(0.000122)	(0.000105)	(0.0162)	(0.0165)	(0.000376)	(0.000257)
Household size	0.320	0.205	-0.0276***	-0.0318***	0.158	0.690	-0.0327***	-0.0415***
	(0.225)	(0.200)	(0.00317)	(0.00282)	(0.380)	(0.470)	(0.00933)	(0.00672)
Per capita household off-farm income	0.225**	0.135	0.00725***	0.00570***	0.551**	0.259	0.0129**	0.00693**
	(0.101)	(0.0954)	(0.00145)	(0.00138)	(0.220)	(0.205)	(0.00540)	(0.00304)
Number of household assets	0.316**	0.385***	0.00611***	0.00691***	0.0947	0.380	0.0142**	0.0138***
	(0.123)	(0.110)	(0.00181)	(0.00158)	(0.257)	(0.322)	(0.00672)	(0.00428)
Education level of head of household	-0.0148	-0.0512	0.000340	0.00275*	-0.323*	0.0590	0.0114**	0.0152***
	(0.112)	(0.107)	(0.00158)	(0.00154)	(0.195)	(0.241)	(0.00513)	(0.00373)
Head of household is married	0.378*	0.460**	0.00498	-0.00179	0.227	0.338	0.0232**	0.00747
	(0.224)	(0.183)	(0.00322)	(0.00268)	(0.386)	(0.425)	(0.0101)	(0.00609)
Expenditure on crop extensions	0.000458	-0.00208	2.80e-05	-2.03e-05	-0.00245	0.000946	1.86e-06	2.72e-05
	(0.00131)	(0.00224)	(1.74e-05)	(3.14e-05)	(0.00544)	(0.00359)	(7.76e-05)	(3.81e-05)
Expenditure on crop extensions^2	2.85e-07	2.09e-06	-1.65e-08	5.86e-08	4.51e-06	-9.10e-07	3.29e-08	-1.80e-08
	(1.20e-06)	(6.21e-06)	(1.40e-08)	(8.19e-08)	(1.06e-05)	(2.19e-06)	(7.83e-08)	(1.67e-08)
Expenditure on livestock extensions	0.00201**	-0.00109	7.14e-06	5.82e-06	0.00584	0.000617	-5.96e-05	-5.12e-05
	(0.000934)	(0.000710)	(6.44e-06)	(9.85e-06)	(0.00628)	(0.00372)	(5.51e-05)	(3.25e-05)
Expenditure on livestock extensions^2	-1.04e-06*	5.75e-07*	-1.68e-09	1.77e-09	-6.91e-06	4.49e-06	5.03e-08	4.02e-08
	(5.28e-07)	(3.43e-07)	(1.44e-09)	(4.35e-09)	(1.10e-05)	(6.27e-06)	(3.40e-08)	(2.61e-08)
A4-lixisols, cambisols, luvisols	-0.198	-0.827*	0.00521	-0.0130**	0.208	1.823*	-0.0234	-0.00559
	(0.490)	(0.423)	(0.00728)	(0.00605)	(0.906)	(1.029)	(0.0219)	(0.0164)
AR-arenosols	-0.644	-0.0569	0.0277**	0.0209**				
	(0.748)	(0.606)	(0.0111)	(0.00833)				
B1-ferralsols, acrisols, lixisols					-0.807	0.753	-0.0197	-0.00227
					(1.312)	(1.294)	(0.0334)	(0.0193)
C1-luvisols, planosols & solonetz	-0.0995	0.657**	0.00652	0.00734	-1.612	-2.291	-0.00611	0.0554*
	(0.363)	(0.320)	(0.00541)	(0.00458)	(1.290)	(2.109)	(0.0279)	(0.0318)

	Panel A: Rural Area				Panel B: Urban Area			
	Subjective measure Food security (1/0)		Objective measure Per capita household consumption		Subjective measure Food security (1/0)		Objective measure Per capita household consumption	
Variables	(1) Female-headed household	(2) Male-headed households	(3) Female-headed household	(4) Male-headed households	(5) Female-headed household	(6) Male-headed households	(7) Female-headed household	(8) Male-headed households
E1-leptosols, regosols, calcisols	-0.574	-0.0829	0.00396	-0.00112	0.160	1.065	-0.0188	0.0186
	(0.392)	(0.328)	(0.00574)	(0.00456)	(0.746)	(0.854)	(0.0150)	(0.0129)
Temperature, winter	1.170	0.201	0.0674**	0.0386	-0.571	0.996	0.312***	0.154*
	(2.333)	(1.946)	(0.0327)	(0.0294)	(5.174)	(5.949)	(0.112)	(0.0889)
Temperature, winter^2	-0.0535	0.0615	-0.00327**	-0.00194	-0.0520	-0.105	-0.0126**	-0.00688*
	(0.0962)	(0.0876)	(0.00136)	(0.00131)	(0.219)	(0.237)	(0.00491)	(0.00369)
Temperature, summer	-9.034	12.52*	-0.131	0.104	-48.54	-79.07**	0.562	0.0931
	(8.215)	(7.164)	(0.119)	(0.104)	(32.72)	(32.02)	(0.723)	(0.342)
Temperature, summer^2	0.259	-0.252	0.00381	-0.00177	1.091	1.759**	-0.0153	-0.00106
	(0.188)	(0.162)	(0.00272)	(0.00236)	(0.771)	(0.750)	(0.0178)	(0.00777)
Precipitation, winter	0.130	0.957**	-0.00564	-0.00952	-0.174	-0.0327	-0.0270**	-0.0134
	(0.294)	(0.423)	(0.00421)	(0.00599)	(0.457)	(0.527)	(0.0106)	(0.00839)
Precipitation, winter^2	0.000319	0.00250	-7.09e-05*	-3.13e-05	-0.00677	-0.00503	5.99e-05	-3.90e-05
	(0.00257)	(0.00246)	(3.81e-05)	(3.51e-05)	(0.00425)	(0.00539)	(9.87e-05)	(7.74e-05)
Precipitation, summer	0.436	0.476	0.00556	0.0111**	-1.242	-1.932**	-0.0110	0.00900
	(0.338)	(0.324)	(0.00487)	(0.00467)	(1.075)	(0.908)	(0.0139)	(0.0128)
Precipitation, summer^2	-0.000686	8.36e-05	-1.83e-06	-1.30e-05*	0.00103	0.000743	-1.73e-05	4.49e-06
	(0.000533)	(0.000528)	(7.66e-06)	(7.63e-06)	(0.00101)	(0.000977)	(1.71e-05)	(1.40e-05)
Temperature, summer* Precipitation, summer	-0.0142	-0.0231*	-0.000246	-0.000422**	0.0538	0.0909**	0.000641	-0.000472
	(0.0142)	(0.0133)	(0.000207)	(0.000189)	(0.0464)	(0.0423)	(0.000632)	(0.000603)
Temperature, winter * Precipitation, winter	-0.00717	-0.0760**	0.000728*	0.000750	0.0433	0.0301	0.00171*	0.00106
	(0.0272)	(0.0360)	(0.000393)	(0.000510)	(0.0420)	(0.0464)	(0.000940)	(0.000730)
Constant	56.22	-170.7**	0.678	-1.638	544.6	874.4**	-7.135	-2.299
	(80.96)	(74.29)	(1.184)	(1.066)	(343.3)	(354.9)	(7.130)	(3.710)
Observations	376	472	376	472	137	119	137	119
R-squared			0.467	0.485			0.634	0.743

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Reference: A2-ferralsols, acrisols & lixisols

Table 12: Food security – Male vs. Females Treatment and Heterogeneity Effects Rural

	Panel A: Subjective Measure			Panel B: Objective Measure		
	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects
Male-headed households	*(i)*0.5372	*(iii)* 0.4672	0.0700***	*(i)*6.4715	*(iii)* 6.3187	0.1142***
	(0.0113)	(0.0087)	(0.0141)	(0.0203)	(0.0152)	(0.0287)
Female-headed households	*(iv)*0.5300	*(ii)* 0.4466	0.0835***	*(iv)*6.5689	*(ii)* 6.4548	0.1528***
	(0.0149)	(0.0101)	(0.0141)	(0.0256)	(0.0154)	(0.0249)
Heterogeneity effects	0.0072	0.0207***		-0.0974***	-0.1361***	
	(0.0159)	(0.0102)		(0.0200)	(0.0085)	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 13: Food security – Male vs. Females Treatment and Heterogeneity Effects Urban

	Panel A: Subjective Measure			Panel B: Objective Measure		
	Male-headed households	Female-headed households	Treatment effects	Male-headed households	Female-headed households	Treatment effects
Male-headed households	*(i)* 0.5693	*(iii)* 0.5537	0.0156	*(i)*6.5584	*(iii)* 6.4812	0.0771
	(0.0268)	(0.0273)	(0.0385)	(0.0539)	(0.0556)	(0.0777)
Female-headed households	*(iv)*0.5755	*(ii)* 0.5089	0.0666*	*(iv)*6.5038	*(ii)* 6.5951	-0.0913
	(0.0218)	(0.0262)	(0.0338)	(0.0490)	(0.0446)	(0.0672)
Heterogeneity effects	-0.0062	0.0448***		0.0546***	-0.1139***	
	(0.0255)	(0.0235)		(0.0404)	(0.0423)	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 14: % distribution of food security under subjective measure – rural vs. urban

	Panel A: Rural			Panel B: Urban		
	Chronic Food Insecurity	**Break-even Food**	**Surplus Food**	**Chronic Food Insecurity**	**Break-even Food**	**Surplus Food**
Male-headed households	45.6	44.1	10.3	40.4	47.0	12.6
Female-headed households	54.5	36.8	8.7	47.6	43.7	8.7

Table 15: Average per capita food consumption: perception vs. actual – rural vs. urban

Panel A: Rural

	Chronic Food Insecurity	Break-even Food	Surplus Food	Q25	Q5	Q75
Male-headed households	130.11	152.21	223.77	119.10	167.46	265.79
Female-headed households	102.18	177.63	132.76	90.71	126.56	203.50

Panel B: Urban

	Chronic Food Insecurity	Break-even Food	Surplus Food	Q25	Q5	Q75
Male-headed households	265.66	252.11	487.06	126.42	208.18	323.62
Female-headed households	224.24	215.14	339.45	121.01	169.17	446.19