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Small-holder Farming, Food Security, and Climate Change in South Africa

Male-Female and Urban-Rural Differences

Byela Tibesigwa and Martine Visser

Environment for Development Centers

Central America
Research Program in Economics and Environment for Development in Central America
Tropical Agricultural Research and Higher Education Center (CATIE)
Email: centralamerica@efdinitiative.org

Chile
Research Nucleus on Environmental and Natural Resource Economics (NENRE)
Universidad de Concepción
Email: chile@efdinitiative.org

China
Environmental Economics Program in China (EEPC)
Peking University
Email: china@efdinitiative.org

Ethiopia
Environment and Climate Research Center (ECRC)
Ethiopian Development Research Institute (EDRI)
Email: ecrc@edri.org.et

Kenya
School of Economics
University of Nairobi
Email: kenya@efdinitiative.org

South Africa
Environmental Economics Policy Research Unit (EPRU)
University of Cape Town
Email: southafrica@efdinitiative.org

Sweden
Environmental Economics Unit
University of Gothenburg

Email: info@efdinitiative.org

Tanzania
Environment for Development Tanzania
University of Dar es Salaam
Email: tanzania@efdinitiative.org

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Abstract

With ongoing climate change, food insecurity is likely to become more widespread in most small-holder and subsistence farm households in sub-Saharan Africa. However, the existence and extent of gendered food (in)security remains unclear. This study extends existing knowledge by assessing gender inequality in food (in)security amongst small-holder farm households in urban and rural areas of South Africa. To do so, we use the gender of the head of household in a treatment effects framework. Our results show that male-headed farm households are more food secure compared to female-headed households, with the latter depending more on agriculture. We further observe that chronic food insecurity is greater and the gender gap in food security is wider amongst rural than urban households. Our results suggest that the current policy interest in promoting both rural and urban agriculture is likely to increase food security in both male- and female-headed households, and to reduce the gender gap.

Key Words: food security, male-headed households, female-headed households, urban, rural

JEL Codes: Q1, C21

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Byela Tibesigwa and Martine Visser*

1. Introduction

Household food security is defined as year-round access to an adequate supply of nutritious and safe food to meet the nutritional needs of all household members: men and women, boys and girls[1] (WB, 2009: p.12). At present, although South Africa has the second largest economy in Africa, with an adequate food supply at the national level, this 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, while 28.3% are at risk of hunger and 26% are actually food insecure, i.e., experience hunger (Shisana et al. 2014). Vulnerability to food insecurity may be more pronounced in female-headed and rural South African households, in comparison to male-headed and urban households (DOA 2002). For example, one-third of South African households are headed by women, and, in 1996, 52% of them spent a mere R1000 per month on food, compared to only 35% of male-headed households who spent so little. Further, while 25% of male-headed households spent R3500 per month, only 8% of female-headed households could afford to pay this amount for food (DOA 2002). Regarding urban and rural patterns, Shisana et al. (2014) show that 32.4% of urban residents of informal settlements and 32.8% of rural villagers are food insecure, compared to South Africans in urban formal areas (19.0%).

In an endeavour to increase household food security and meet the Millennium Development Goals (MDGs), South Africa's programmes and interventions are strongly grounded in agriculture (RSA 2014), as elsewhere around the globe (FAO 2014). In South Africa, an estimated 20.7% of households engage in agriculture, and 65% of these households use agriculture purely as a subsistence strategy to meet household food demand (RSA 2014).

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* Corresponding author: Byela Tibesigwa, Senior Research Fellow, Environment for Development – Tanzania (EfDT), Department of Economics, University of Dar es Salaam, Box 350, 45 Dar es Salaam, Tanzania. Email: byela.tibesigwa@gmail.com. Martine Visser, Senior Research Fellow, Environmental-Economics Policy Research Unit, School of Economics, University of Cape Town, Private Bag X3, Rondebosch 7701, Cape Town, South Africa. We acknowledge helpful comments from Peter Berck and the participants in the 9th Environment for Development (EfD) Initiative conference. We also thank EfD and ERSA for financial support.

[1] Household food security is generally linked to food security, which 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).

With the arrival of climate change, however, the strategy of using small-scale subsistence farming to promote food security continues to look bleak. Food security, or the lack thereof, is by nature multifaceted; 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). Added to this, female-headed households continue to increase in sub-Saharan Africa (Bongaarts 2001; Horrell and Krishnan 2007), bringing an increase in household gender inequalities. South Africa[2] appears to have the highest number of female-headed households, currently estimated to be 41.9%. This is relatively high, considering that the range of female-headed households' in West Africa is between 9.5% and 22.9%, while in East Africa it is between 24.4% and 29.5% (WB 2016).

With increasing concerns about the increase of female headship, poor levels of household food security, the dependence on agriculture to improve these poor levels and the detrimental effects of climate change on agricultural productivity, areas that were somewhat dormant have found their way back into the literature with growing interest. The prime examples include male-female[3] and urban-rural[4] small-holder agriculture. However, limited evidence exists on household gender inequalities in food security and the participation of households in agricultural activities to increase food security in South Africa and the greater part of sub-Saharan Africa. This has been documented by the Food and Agriculture Organisation of the United Nations (FAO), which notes 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).

In an attempt to provide the needed evidence to increase our understanding, this study explores the following: first, the role of agriculture in the 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; and third, the impact of gender of

[2] In general, South Africa has one of the highest levels of inequality in the world (Modirwa and Oladele 2012). Referring to gender inequalities in South Africa, Walker (2003) notes that: 'Women are discriminated against; leadership in rural communities is likely to be male; men and women perform different tasks in households and communities and that these are differently valued; women are the victims of gender-specific violence, and women are over-represented among the poor, the very poor and the landless (Walker 2003: p.23).

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

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

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 in food security in rural areas of Kenya and South Africa. In our study, we consolidate past studies and compare male-female and urban-rural small-holder subsistence farm households, who by definition engage in agriculture to boost household income and/or food levels. The role of urban agriculture in food security has received less attention, as indicated in a FAO report: "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 peri-urban agriculture is an activity in which the poor are disproportionately represented" (Hoornweg and Munro-Faure 2008, p.10). Hence, our study will provide new insights by addressing urban agriculture, in addition to rural agriculture, in relation to food security.

Documenting the current male-female and urban-rural evidence is important from a policy perspective because gender inequalities, rural development and urban planning are at the heart of policy concerns of most countries in developing regions. In our investigation, we use the 2008 nationwide National Income Dynamics Study (NIDS) and a treatment-effects regression framework to tease out the gender differences in food security of rural and urban small-holder farmers in South Africa. To capture food security, we use both a subjective and an objective measure. The former is a self-reported perception of household food, where household food security takes a value of one and food insecurity takes a value of zero, while the objective measure is per capita household monthly food consumption. The conceptualisation of these measures follows FAO (2002) and previous studies.

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 measures. Second, extending the study of Kassie et al. (2014) and Tibesigwa et al. (2015), we observe that, although male-headed households are more food secure in both rural and urban areas, the gender gap in food security is wider 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 having less than adequate food, i.e., the experience of hunger. This is in contrast to urban households, who are more likely to report either breaking even (i.e., household food was just adequate) or surplus food (i.e., household food was more than adequate, and the household was 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 for both male- and female-headed households, while summer climate is more significant in predicting the food security of female-headed households.

The rest of the paper is structured as follows. Section 2 summarizes the literature on food security and agriculture among 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 Millennium Development Goals (MDGs), 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 to note 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). Yet another FAO report, “Growing Greener Cities in Africa, notes 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” (FAO 2012, p.5). This alludes to the fact that food security, or the lack thereof, is both a rural and an urban problem. Agriculture, and, more specifically, urban (Rogerson 2003; Zezza and Tasciotti 2010; FAO 2012) and rural agriculture (FAO 2014) appear to be one of the solutions to this stubborn problem, especially if practiced by poor households.[5]

[5] Smit et al. (1996) notes the following about 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).

In South Africa, approximately 20.7% of all households engage in agriculture, which is equivalent to about three million households (RSA 2014).

However, agriculture will not have similar effects on rural and urban households' food security owing to the distinctive features of the two groups. That is, there are substantial variations between urban and rural areas (e.g., economic opportunities, population density, access to financial markets, tenure security, and access to water), which are likely to affect agricultural productivity in different ways.[6] Even gender roles differ between rural and urban areas (Oberhauser et al. 2004). Hence, further complicating the agricultural productivity differences in urban and rural areas is gender inequality (Horvoka 2005; Crush et al. 2011). In general, female-headed households are more vulnerable than male-headed households (Babatunde et al. 2008; Mallick and Rafi 2010; Kassie et al. 2014). This inequality is also evident amongst small-holder farming households (Babatunde et al. 2008; Tibesigwa et al. 2015). For example, it is estimated that 61% of South African farmers are women and close to two-thirds of them use agriculture as a way to increase household food (Altman et al. 2009). These female-headed households have limited access to economic resources to invest in agriculture so as to increase productivity, and this is more evident in rural areas (Posel 2002; Van Averbeke 2007). This is why the role of agriculture in enhancing food security is multidimensional. Therefore, to be effective, policies need to be designed with these widespread geographical and gendered differentials in mind. But first, this requires an in-depth understanding of the linkages between agriculture and food security among male and female farmers in urban and rural areas. In this study, we set out to unveil these linkages.

As previously noted, even without considering gender, there are large variations in the contribution of urban and rural agriculture to household livelihood and food security. However, although urban agriculture is described as a survival strategy (De Zeeuw et al. 2000; Mougeot 2000), especially amongst the poor who reside in urban areas of developing countries (De Zeeuw et al. 2000; Deelstra et al. 2000; Thornton 2008), the contribution of urban agriculture to food security is still unclear (Armar-Klemesu et al. 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, the scientific evidence on its contribution to food security is relatively well-

[6] Other noteworthy features include food prices, which are higher in urban than in rural areas (Drechsel and Dongus 2010; Armar-Klemesu 2000). Newland (1980) compared prices of food in five developing countries and found urban prices to be 10-30% higher 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; FAO 2012).

documented. This could be because most rural Africans engage in agriculture. For example, in Madagascar, 73% of the rural population engages 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). Recently, however, there has been a resurgence of interest in both rural and urban agriculture[7] (Rogerson 2003; Battersby 2012), fuelled by climate change, rapid urbanisation, food insecurity and the inter-related high poverty levels[8] (Smit et al. 1996; Battersby 2012).

Despite this renewal of interest, 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 agricultural practices and their contribution to food security. 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.

Staying with agriculture, but introducing gender, we outline the gendered differences between urban and rural agriculture. To begin, urban (Crush et al. 2011) and rural small-holder agriculture is dominated by women (Smit and Nasr 1992), who remain socio-economically disadvantaged in both areas (Hovorka 2006). This assertion is supported by Van Averbeke (2007), who observed this in the Limpopo and Mpumaanga provinces of South Africa, where urban farming was mainly practiced by women, primarily to produce vegetables for household consumption. Similarly, 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 2000). Similarly, in Yaounde (Cameroon), Brazzaville (Republic of the Congo), Bissau (Guinea-Bissau) and Lusaka, Zambia and Bangui (Central Africa Republic), most of the urban farmers are women who participate in farming because of their poor socio-economic position (FAO 2012). The

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

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

participation of women in agriculture is likely to be higher amongst those who head households (Crush et al. 2011; FAO 2012).

Land used for small-holder farming differs widely between rural and urban areas. 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 2000; Drechsel and Dongus 2010), including informal and illegal land, e.g., vacant land not suitable for housing (De Bon et al. 2010). By contrast, farmers in rural areas use traditionally accessed land (De Bon et al. 2010). Access to land is one of the main obstacles to urban agriculture (Rogerson 2003; Horvoka 2005) and affects female more than male farmers (May and Rogerson 1995; Jacobi et al. 2000; Crush et al. 2011). For example, in the Eden district of the Western Cape Province of South Africa, Modirwa and Oladele (2012) found that 90.3% of male-headed households cultivated on 3-4 hectares of land, while only 78.9% of female-headed households used plots of similar size. Making a similar observation, Van Averbeke (2007) found that urban women farmers in the Limpopo and Mpumaanga provinces of South Africa mostly owned home gardens or cultivated in small plots around the household; they noted that access to land for women farmers continues to be a challenge. Because rural agriculture is mainly 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. Hovorka (2006) made 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 the government.

Land ownership challenges in South Africa are quite different from the rest of sub-Saharan Africa and are heavily tied to the past apartheid era. Land reform, which began at the dawn of democracy, continues to be at the center of the policy agenda in South Africa. Currently, land reform calls for tenure reforms, restitution and land redistribution. Additionally, the government approved a Land Reform Gender Policy in 1997 to improve land tenure security and ownership amongst women. However, female-headed households are less represented in the reform programmes, and male-headed households currently own larger plots and have more access to land in comparison to female-headed households (Walker 2003).

Further, while women urban dwellers often produce on a micro-scale, men predominate in larger farms (Jacobi et al. 2000), as observed in Dakar, Sudan and Dar es Salaam, Tanzania (Horvoka 2005); the same has been noted about Lilongwe and Blantyre in Malawi (Mkwambisi et al. 2011) and Lagos, Nigeria (FAO 2012). Similarly, in the Eden district of the Western Cape Province of South Africa, Modirwa and Oladele (2012) found that 90.3% of male-headed households cultivated on 3-4 hectares of land, while only 78.9% of female-headed households used land of similar size. This may be explained by the multiple burdens faced by women which limit their participation in agricultural activities[9] (Danso et al. 2004; Crush et al. 2011).To give an example, women in the rural areas of South Africa engaged in multiple part-time activities to generate additional income for their households. Some of these activities include selling palm products and reed mats, which generates about R100 to R2500 per year. Other activities include the collection of fuelwood and herbs (Shackleton et al. 2001). The multiple burdens are likely to be more pronounced in female heads of households (Crush et al. 2011).

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. 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 agricultural 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 (FAO 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 (FAO 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 regard to agricultural extensions, i.e., productivity-enhancing inputs. Urban farmers are more likely than rural farmers to have access to these extension, due to close proximity to the market (De Bon et al. 2010). As observed in Tunisia, where urban farmers had easier access to market information and inputs (FAO 2012), this pattern

[9] This 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 both inside the household (i.e., family responsibilities) and outside (i.e., work responsibilities). Because of these extra burdens, women are likely to limit their farm participation (Danso et al. 2004; Crush et al. 2011).

is likely to be observed among male farmers than among women, who have lower incomes (Horvoka 2005).

Access to affordable credit remains a major challenge amongst small-holder farmers. As a result, most of these farmers opt to borrow from informal financial institutions. Access to both formal and informal credit is more common among male farmers and male-headed households than among female-headed households (Kameri-Mbote 2006). In South Africa, for instance, most borrowers of agricultural credit are male heads of households. Access to credit improves with increases in education and farm size (observed in South Africa by Sebopetji and Belete, 2009), placing poor women at an additional disadvantage.

Another important farm input is water, which is more likely to be a challenge for urban than for rural farming (Rogerson 2003). While rural small-holder agriculture is mainly rain-fed, urban agriculture depends on irrigation. However, this will increasingly become a disadvantage for rural farming due to on-going climate change. For example, rice farming in rural Ghana is mainly rain-fed (Drechsel and Dongus 2010). While there is a segment that relies on irrigation in urban areas, irrigation is a challenge for women urban farmers in South Africa, who rely on water from standpipes, which is transported either by hosepipes or buckets (Van Averbeke 2007).

The type of water used for agriculture is linked to food safety risks. That is, urban agriculture is more likely than rural agriculture to be associated with pollutants from industries or waste water (De Bon et al. 2010) because the rural dependence is more on rain and natural habitats. For instance, because of untreated waste water and poor soils, in Yaounde, Nairobi and Dakar (cities in Cameroon, Kenya and Senegal, respectively), urban vegetables were found to be inferior compared to those produced in rural areas (FAO 2012).

Turning to the role of climate change, Africa will experience the effects more than any other continent (FAO 2012). This will not only affect agricultural productivity in urban and rural areas, it will also accelerate migration from rural to urban areas, further increasing urban poverty and food insecurity (FAO 2012). Because rural agriculture is rain-fed, climate change effects are likely to be more pronounced in rural than in urban areas. For example, Malawian agriculture, which is mainly subsistence in nature, is mostly rain-fed, and hence susceptible to climate change (FAO 2014). The same can be said about rice farming in Ghana, in that it is also rain-fed (Drechsel and Dongus 2010).

There is also a rural bias in policies, i.e., rural agriculture has been a priority for policy makers in the past, 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 Côte d'Ivoire, rural farmers enjoy the national agricultural extensions service, which are geared toward rural but not urban agriculture (FAO 2012). In yet another example, rural agriculture in South Africa is more visible in the research and policy arena, although urban agriculture has been supported by the government since the 1990s.[10]

So far, most studies on food security have studied these multiple dimensions in isolation, concentrating on rural agriculture alone (e.g., Maxwell et al. 1998; Tibesigwa et al. 2015b), or urban agriculture (e.g., Zezza and Tasciotti 2010; Lynch et al. 2013), or male and female farmers 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 factors by assessing urban-rural and male-female farm households. For instance, Maxwell et al. (1998) demonstrated the importance of urban agriculture to the 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 an observation similar to that of Slater (2001), i.e., they found that urban agriculture was not a significant contributor of household food, and that households mainly depended on supermarkets and the informal sector. In 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 with Babatunde et al. (2008).

Further showing the gendered differences in agriculture, in Lilongwe and Blantyre, cities in Malawi, Mkwambisi et al. (2011) observed that female-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

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

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 treatment-effects regression 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 households respectively. G is the dummy variable with 1 representing male-headed households, while 2 captures female-headed households, and **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 framework will produce unbiased estimates.

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1\mu} \\ \sigma_{12} & \sigma_2^2 & \sigma_{2\mu} \\ \sigma_{1\mu} & \sigma_{2\mu} & 1 \end{pmatrix} \tag{3}$$

The advantage of this approach is that it allows us to estimate two separate equations, i.e., (1) and (2), for male- and female-headed households, thereby enabling us to analyse the differential impact of **X** on y_1 and y_2, where the assumption is that **X** has a different impact on y_1 than on y_2 , 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:

$$\mathrm{E}(y_1|G = 1) = \mathbf{X}_1\beta_1 \quad (4)$$

$$\mathrm{E}(y_2|G = 2) = \mathbf{X}_2\beta_2 \quad (5)$$

$$\mathrm{E}(y_2|G = 1) = \mathbf{X}_1\beta_2 \quad (6)$$

$$\mathrm{E}(y_1|G = 2) = \mathbf{X}_2\beta_1 \quad (7)$$

where Equations (4) and (5) are the actual expected outcomes, while Equations (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 households respectively, while *(iii)* and *(iv)* represent the counterfactual food security status. In Table 1, TT is synonymous with the effect of treatment on the treated, i.e., it denotes the effect of gender on the food security that male-headed households would experience if they maintained 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.:

$$\mathrm{TT} = \mathrm{E}(y_1|G = 1) - \mathrm{E}(y_2|G = 1) = \mathbf{X}_1(\beta_1 - \beta_2) \quad (8)$$

Similarly, TU is synonymous with 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 have the same returns as male-headed households (Kassie et al. 2014). In Table 1, this is the difference between *(iv)* - *(ii),* i.e.:

$$\mathrm{TU} = \mathrm{E}(y_1|G = 2) - \mathrm{E}(y_2|G = 2) = \mathbf{X}_2(\beta_1 - \beta_2) \quad (9)$$

Further, BH_1 and BH_2, in Table 1, measure the base heterogeneity for male- and female-headed households respectively; they capture the effect of unobservable characteristics that cause the gender differences in food security (Kassie et al. 2014). These are presented in Equations (10) for males and (11) for females:

$$\mathrm{BH}_1 = \mathrm{E}(y_1|G = 1) - \mathrm{E}(y_1|G = 2) \quad (10)$$

$$\mathrm{BH}_2 = \mathrm{E}(y_2|G = 1) - \mathrm{E}(y_2|G = 2) \quad (11)$$

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 households and measure the impact of gender on food security in rural and urban areas.

Because we are interested in gender inequalities between male- and female-headed households, we assume that household food is equally shared between household members, and ignore within-household food inequalities. This dichotomisation of households according to the gender of the head of household and measuring gender inequalities at the household level is not new (see, e.g., Kennedy and Peters 1992; Mallick and Rafi 2010. Kassie et al. 2014) and is motivated by the current evidence that suggests that the head of household is likely to be the decision maker who represents household members on matters regarding household consumption, production and investment[11] (Kishor et al. 1996). Posel (2001) documents such evidence in South Africa. We do acknowledge that such an approach is simplified as there are likely to be gender inequalities within the household as well. 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. In general, most of the females who head households in South Africa are not married, while a smaller percentage have either an absent or deceased partner (Posel 2001). Some qualitative literature has even found that women who head households in South Africa value the control they have over their lives and resources and as a result avoid permanent relationships that may in turn reduce or eliminate this control (Preston-Whyte and Zondi 1989).

3.2. Data and Variable Description

This study measures gender household food security amongst small-holder farmers in rural and urban areas using the 2008 National Income Dynamics Study[12] (NIDS). NIDS is a nationwide survey conducted primarily to collect information on the livelihoods of South Africans using 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 (SALDRU 2008). In the current study, we use the 2008 survey with approximately 1100 households who engage in small-holder subsistence farming. Note that the definition of small-

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[11] This concept is mainly borrowed from the unitary household model that views a household as hierarchical and is commonly applied in South Africa and the rest of sub-Saharan Africa. However this concept is often criticised by the bargaining power literature that views household's behaviour as strategic interaction of household members (Posel, 2001). It is unlikely that such bargaining power between household members exists in such settings as sub-Saharan Africa.

[12] NIDS is managed by the Southern Africa Labour and Development Research Unit (SALDRU) in the University of Cape Town.

holder farms relates to the size of the farm land, which often ranges between less than one hectare and about ten hectares of land (FAO, 2008), while subsistence farming is defined as 'a form of agriculture where almost all production is consumed by the household, often characterized by low-input use, generally provided by the farm'[13] (FAO 2008: p. 93). The NIDS household questionnaire collected information on crop farming and livestock activities for subsistence purposes, i.e., how much of the agricultural output was consumed by the household, and how much was sold or given away as gifts. The household questionnaire also collected information on household food spending by asking about the value of consumption of foodstuff in the last 30 days, including the value of foodstuff that was received as a gift or payment or was produced by the household. In addition to household food spending, the questionnaire captured households' perceived food security using a point scale.

As our outcome, we use two measures of *household food security* so as to compare the robustness of our results to a different definition of food security. As previously mentioned, household food security is a multi-dimensional concept. Recall the definition: all household members have access to a nutritionally adequate, safe and stable food supply, which is available and utilised throughout the year. Availability captures quantity, quality and diversity of food, while accessibility consists of adequate infrastructure, e.g., roads, and economic access, e.g., price. Stability is concerned with risks to security, e.g., price instability and fluctuation in food supply, including political instability. Utilisation includes nutritional failure, e.g., stunting of children's growth and anaemia in pregnant women (FAO 2014). Thus, the concept of food security is broad and therefore best captured by a composite measure. However, there is no agreed-upon composite measure, and all the information relevant to food security is often not captured by survey data. In an effort to address these measurement challenges, the FAO held a scientific symposium in 2002, followed by a report entitled 'Measurement and Assessment of Food Deprivation and Under-nutrition'. We closely follow the concepts developed in this report and used in past studies (see Feleke et al., 2005; Di Falco et al., 2011; Mallick and Rafi 2010; Kassie et al. 2014; Tibesigwa et al., 2015).

The first outcome is subjective and is derived from self-reported perceptions. Households were asked: 'Concerning your household's food consumption over the past month, which of the

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[13] This is in sharp contrast to commercial farmers, which are defined as 'farmers that produce agricultural products intended for the market to be delivered, sold or stored at commercial structures and/or sold to end consumers, feedlots, poultry farms, dairies, etc., fellow farmers and direct exports. They generally use high levels of inputs, (FAO: p.9).

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 household 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.

We augment the subjective measure with a second outcome; this is an objective measure defined as per capita household consumption. This includes household consumption of food purchased, produced by farming, given as a gift and given as a 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. These include age, education, gender and the 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 a rural or an urban area. We also include farm extension, soil characteristics, and district-level mean precipitation and temperature.[14] We use long-term climate data, which consists of 50 years' average temperatures and precipitation.

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 gifts and (3) the output that is sold by the household. This extends on Tibesigwa et al. (2014). Table 2 shows the distribution of agricultural output, Panel A depicts the pooled sample, Panel B displays rural households and Panel C shows urban households.

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 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%), while a little was either consumed (26.7%) or given away as gifts (24.3%). This confirms the subsistence nature of crop agriculture amongst these households, in that most of the agriculture output is kept for consumption (Tibesigwa et al. 2014). Columns 2 and 3 compare male- and female-headed households, and show that, while male-headed households

[14] The soil data is from the Institute for Soil, Climate and Water and contains A4-lixisols, cambisols, luvisols, AR-arenosols, B1-ferralsols, acrisols, lixisols, C1-luvisols, planosols, solonetz, E1-leptosols, regosols, and calcisols.

kept only 44.7% of crop output for consumption, female-headed households kept 71.7% of the crop output. This is consistent with the current literature. We further observe in Columns 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 gifts (40.8%) or sold (34.8%).

When we move to Panel B in Table 2, which compares male- and female-headed households in rural areas, we observe that female-headed households mainly consumed their crop output (68.8%), 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. 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 it (28.6%), but the majority of it is given away as gifts (42.5%).

Amongst the urban sample in Panel C, we find that, as in rural areas, female-headed households consume the majority of their crops (85.3%), and very little is either sold (6.9%) or given away as gifts (7.9%). Amongst the male-headed households in urban areas, 54.3% of the crops are kept for consumption, which is almost half of the amount that female-headed households keep for consumption, and the remaining 38.3% is sold, while 7.4% is given away as gifts. Again, this is consistent with the literature. As before, we find that most livestock 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 in rural areas, who only keep 68.8%. We also observe that male-headed households in urban areas keep slightly higher crop output for consumption (54.3%) in comparison 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 per capita household consumption. Recall that our objective measure is per capita household consumption (using monetary values) and includes household consumption of (1) purchased food, (2) food produced from farming, (3) food received as gifts and (4) food received 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 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 measures show 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 compared to female-headed households. Also, it appears that on average both male- and female-headed households farm in B1-ferralsols, acrisols, and lixisols soils, with approximately 14ºC temperature and 28mm of precipitation in winter, and 20 ºC 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 households. 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 a 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., Panels 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 Panels A and B are that household size and education of the head of household are significant in the latter but not in the former.

Overall, the results are in line with our expectations and consistent with the current literature. To give an example, relatively similar observations can be found in Kassie et al. (2014). As we observe, 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, and 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 location does not appear to predict food security under the objective measure. Also, being married increases the likelihood of reporting food security, and this is more significant in male-headed households.

Households' expenditure on crop farm extensions (i.e., fertilisers, manure, ploughing and seeds) is significant amongst female-headed households, while expenditure on livestock farm extensions (i.e., livestock feed, dips and veterinary services) is significant in male-headed households. Expenditure on these extensions appears to have a non-linear relationship with food security, which is consistent with Di Falco et al. (2011). 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 more likely to cultivate fertile land compared to male-headed households. Winter precipitation and temperature predict food security in both male- and female-headed households, while summer precipitation and temperature predict food security only 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 households in comparison to female-headed 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 households 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 present 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 have consumed only 0.9% (0.064) more than female-headed households if they had the same characteristics as female-headed households. The statistical significance of the heterogeneity effects in Panels A and B indicates that there are unobserved factors that make male-headed households more food secure than female-headed households. Overall, this suggests that male gender of the head of household 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-evens are those who reported that their household food was just adequate and are therefore at risk of hunger. 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 insecurity, 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 insecurity, 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 insecurity, break-even/at-risk 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 insecurity, break-even/at-risk 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 measures. Second, the average per capita consumption in Column 3 under 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/at-risk (Column 2) and Q5 (Column 5). In Tables 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 insecurity 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 the 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, and marital status are more significant in female-headed households, while household income and expenditure on livestock extension are significant 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 significant effects of 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 Tables 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 Tables 12 and 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 the objective measure, i.e., Panel B in Tables 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 measures reveal that male-headed households are more food secure. Further, we observe a 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 Tables 12 and 13. Added to this, while this gap is significant at the 1% level in rural areas, it is, however, insignificant in urban areas.

Under the objective measure in Panel B in Tables 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 the 1% level. Under the counterfactual in *(iv)*, Panel A in Tables 12 and 13 shows 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. A similar pattern emerges in Panel B, where we find a 2.4% and -1.4% gap in rural and urban areas, 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 insecurity (54.5%) than did female-headed households in urban areas (47%). Similarly, more male-headed households reported chronic food insecurity 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 the gender of the head of household on food security of small-scale farm households in rural and urban areas. We employ the switching treatment-effects regression framework to tease out the gender and geographical effects, using 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 quantity of household assets are the main determinants of household food security. While the quantity of household assets appears to have an almost equal impact on food security of male- and female-headed households, off-farm income 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 households, 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 specifically, 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. Because 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 are those in urban areas, where chronic food insecurity refers to having less than adequate food, i.e., the experience of hunger. In contrast, urban households are more likely to report break-even, i.e., household food was just adequate and hence they were at risk of experiencing hunger, and surplus food, i.e., household food was more than adequate and therefore they are food secure.

Overall, our results support the growing interest of the South African government in promoting rural agriculture and development. This is because it appears 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 policies on urban agriculture should continue to be emphasised, in light of the effects of climate change on agriculture productivity and rural-urban migration.

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Appendix

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 (1)	Male-headed households (2)	Female-headed households (3)	Pool (4)	Male-headed households (5)	Female-headed households (6)	Pool (7)	Male-headed households (8)	Female-headed households (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 (1)	Male-headed households (2)	Female-headed households (3)	Pool (4)	Male-headed households (5)	Female-headed households (6)	Pool (7)	Male-headed households (8)	Female-headed households (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. Female

	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)
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)

	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
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. Female 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. Female 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. Female 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. Female 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

	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
					(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)
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)

	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
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. Female 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 (0.0113)	*(iii)* 0.4672 (0.0087)	0.0700*** (0.0141)	*(i)*6.4715 (0.0203)	*(iii)* 6.3187 (0.0152)	0.1142*** (0.0287)
Female-headed households	*(iv)*0.5300 (0.0149)	*(ii)* 0.4466 (0.0101)	0.0835*** (0.0141)	*(iv)*6.5689 (0.0256)	*(ii)* 6.4548 (0.0154)	0.1528*** (0.0249)
Heterogeneity effects	0.0072 (0.0159)	0.0207*** (0.0102)		-0.0974*** (0.0200)	-0.1361*** (0.0085)	

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

Table 13: Food Security – Male vs. Female 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 (0.0268)	*(iii)* 0.5537 (0.0273)	0.0156 (0.0385)	*(i)*6.5584 (0.0539)	*(iii)* 6.4812 (0.0556)	0.0771 (0.0777)
Female-headed households	*(iv)*0.5755 (0.0218)	*(ii)* 0.5089 (0.0262)	0.0666* (0.0338)	*(iv)*6.5038 (0.0490)	*(ii)* 6.5951 (0.0446)	-0.0913 (0.0672)
Heterogeneity effects	-0.0062 (0.0255)	0.0448*** (0.0235)		0.0546*** (0.0404)	-0.1139*** (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