ORIGINAL PAPER

CrossMark

The impact of the homestead food garden programme on food security in South Africa

Bahta Yonas Tesfamariam[1] · Enoch Owusu-Sekyere[1] · Donkor Emmanuel[2] · Tlalang Boipelo Elizabeth[1]

Abstract

The South African government has implemented homestead food garden (HFG) programmes directed at enhancing food production in order to reduce food insecurity, malnutrition, poverty and hunger. The present paper evaluated the impact of this programme on household food insecurity using surveys of 500 households. Endogenous switching regression, propensity score matching and household food insecurity average scores were employed in our analysis. Our findings demonstrated that participation in an HFG programme could significantly enhance the food security status of participants by increasing household food supply and consumption as well as by income derived from selling any excess production from the garden. Specifically, our empirical findings showed that participation in the HFG programme significantly reduced food insecurity among rural households by as much as 41.5%. Therefore, we recommend that policy makers should encourage more rural households to participate in the programme in order to reduce their food insecurity. Facilitating easy access to credit, extension services, fertilizer, irrigation facilities and land are policy options needed to promote farmers participation in HFG programmes. Furthermore, the formation of farmer-based organizations and the building of positive perceptions about HFGs are some of the key policy options that can be employed to improve households' participation in the programme. Promotion of education, participating in off-farm activities, access to market, irrigation, extension and credit, and adoption of fertiliser are some policy interventions that can reduce food insecurity among rural house holds whether or not they participate in the HFG programme.

Keywords Food insecurity · Homestead food garden programme · Rural households · Selection bias · South Africa

1 Introduction

The rapid global increase in population, urbanization and climate change have major consequences for global food production and food security (FAO 2009). The world's population is expected to reach over 9 billion by 2050, whereas existing statistics indicate that over 600 million people globally have inadequate access to quality food (Sasson 2012). In South Africa, hunger and food insecurity is more acute among rural households (Van Zyl and Kirsten 2010). Consequently, the South African government and stakeholders in the agricultural sector have implemented HFG programmes to address food insecurity and hunger (Du Toit et al. 2011; Pienaar and Fintel 2013). The HFG programme is one of the strategies under the South Africa and Integrated Food Security Strategy (SAIFSS) (DAFF 2014).

HFG is defined as a farming system, which combines different physical, social and economic functions on an area of land around the family home to produce food commodities such as vegetables (Galhena et al. 2013). The HFG programme in the Gauteng province of South Africa came into existence in 1997 and was one of the projects identified as the government's response to food insecurity, poverty, hunger and malnutrition. It also seeks to increase the income of households through sales of surplus production. The main aim of the programme is to ensure food security for everyone in Gauteng province. The HFG programme targets the most vulnerable groups, namely elderly, women, youths, people living with

✉ Enoch Owusu-Sekyere
   kofiwusu23@gmail.com; esekyereufs@gmail.com

✉ Tlalang Boipelo Elizabeth
   Pelonk@yahoo.com

   Bahta Yonas Tesfamariam
   Bahtay@ufs.ac.za; Yonas204@yahoo.com

   Donkor Emmanuel
   edonkor.knust@gmail.com

[1] Department of Agricultural Economics, University of the Free State, 339, Internal box 58, Bloemfontein 9300, South Africa

[2] Department of Agricultural Economics, Extension and Agribusiness Kwame Nkrumah, University of Science and Technology PMB, KNUST, Kumasi, Ghana

disabilities and HIV/AIDS, the unemployed and military veterans in Gauteng's urban and peri-urban areas. Participation in the programme is therefore not randomised and consequently an impact evaluation of such a programme requires methodology that accounts for selection bias. The programme offers training in vegetable production and provides beneficiaries with production packages that enable them to produce food to feed their families and sell surplus production in order to generate an income (Rudolph 2012).

Specifically, beneficiaries receive some training in the practice of HFG as well as starter packs according to the Gauteng Food Security Standard of Operation Programme (SOP). Training lasts 3 working days. After successful participation in the training part of the programme, starter packages are given to the participants (DACE 2002). Packages include a spade, fork, rake, hand hoe, two 30 dcm^3 bags of compost, a 10-l watering can and six types of seeds (spinach 10 g, beetroot 10 g, onion 7 g, carrot 8 g, beans 15 g, and tomato 2.5 g) (GADS 2006). Only one starter pack per household is given, even if more than one person from a household participates in the training programme. Beneficiaries of the programme attend meetings with the local leadership (ward councillors, ward committees, etc.) and the programme implementers in order to discuss the sustainability of the programme. Public meetings are also held to explain the benefits of the programme to community members and to motivate people to participate in the programme.

Advocates of HFG argue that the system is well adapted to local agronomic and resource conditions, and to cultural and food preferences. Thus HFG is regarded as a sustainable agricultural practice for improving food security and nutrition in rural areas, and enhancing economic growth (Galhena et al. 2013). Moskow (1996) has further argued that a food production system, which is controlled by households is more reliable and sustainable than nutrition interventions, which primarily rely on government goodwill and financial support. Some studies in South Africa have revealed that HFGs contribute to vitamin A intake among children and supplement household food and income (Faber et al. 2002; Nkosi et al. 2014), as well as boosting nutritional security (Faber et al. 2011). From a global perspective, participation in HFGs have a significant impact on nutrition and food security (Bushamuka et al. 2005; Schreinemachers et al. 2016). Bushamuka et al. (2005) and Schreinemachers et al. (2016) showed that participation in a homestead gardening programme in Bangladesh helped to control vitamin A deficiency and also addressed micronutrient undernutrition. Galhena (2012) investigated the role of home gardens in enhancing food security in Sri Lanka and found that home gardens offer households a diversity of fresh and nutritionally rich food products which increased their food security status. Nonetheless, the participatory decision of households, the determinants of households' participation in HFGs and their impact on households food insecurity status have not been rigorously explored, particularly in South Africa. Therefore, existing information on the determinants and impacts of an HFG programme is not sufficient to guide policy decisions in achieving rural household food security. Although some authors have related HFG interventions to food security, they principally employed descriptive analysis, which is less rigorous in providing relevant and in-depth policy information (Maroyi 2009; Talukder et al. 2000; Tho Seeth et al. 1998; Trefry et al. 2014).

Hence, the objective of this study was to rigorously determine the factors that influenced rural households' decisions to participate in an HFG programme. The impact of an HFG programme on food insecurity among rural households in the Gauteng province of South Africa was assessed and the determinants of food insecurity among participating and non-participating households was explored. Two parametric impact-modelling techniques (endogenous switching regression and propensity score matching) that accounted for selection bias were employed. Overall, the study provided relevant information required for policy decision makers to make efficient modifications to existing policies. Subsequently, the sustainable dimension of HFGs (e.g. poverty alleviation and food security improvement) was increased and is complicit with the post-2015 development agenda for sustainable development goals, which seeks to end poverty and hunger. To the best of our knowledge, this is one of the first studies to examine the impact of HFGs on food insecurity, accounting for the selectivity effect arising from both observed and unobserved factors.

2 Material and methods

2.1 Conceptual framework

Figure 1 provides a conceptual framework that summarises the causality effects of participation in HFGs on food security. As depicted, individuals' decisions to participate in the HFG programme were influenced by a number of factors such as socioeconomic, institutional, asset endowments, and the individual's perception of the benefits associated with the programme. Participation in an HFG programme together with socioeconomic, institutional and asset endowments determined the food security of an individual household. Participation in HFGs was expected to increase food production of the participants, and hence, increase their food security (Faber et al. 2011; Galhena et al. 2013; Nkosi et al. 2014). The socioeconomic variables included in the empirical models were age, education, household size, gender, income, land size, labour and participation in off-farm activities (Abdulai and Huffman 2014; De Cock et al. 2013; Huffman 2001; Koundouri et al. 2006; UNWFP 2006). The institutional

Fig. 1 Conceptual framework for causality of HFG programme on food security
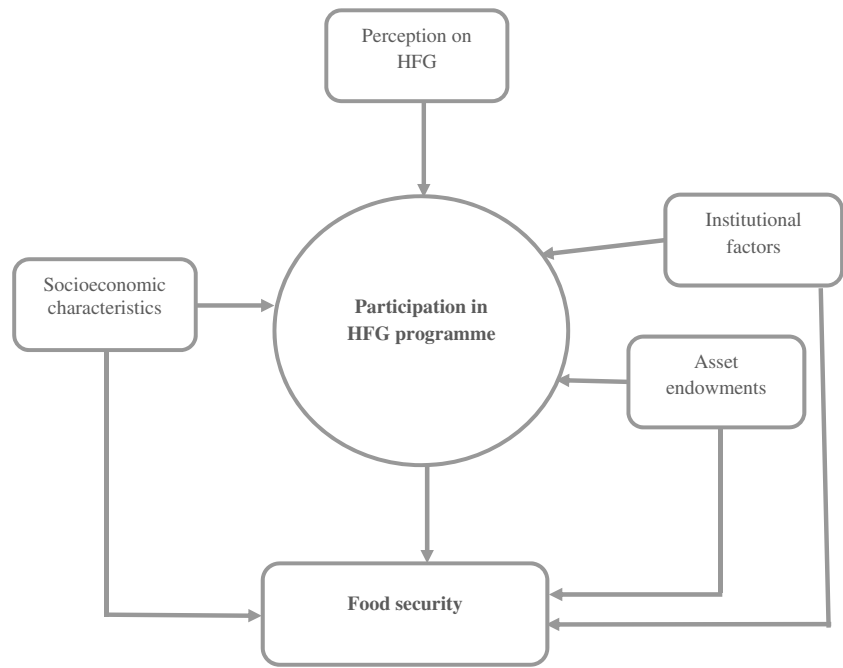
variables hypothesized to influence participation in an HFG programme encompassed access to extension, credit, support, social network, distance to nearest market and access to market (Abdoulaye and Sanders 2005; Alam et al. 2012; Bandiera and Rasul 2006; Kassie et al. 2011). Household asset endowments such as livestock and farm implements can be used as proxies for household wealth (Abdulai and Huffman 2014). Two main impact evaluation methods, namely endogenous switching regression and propensity score matching were employed to quantify the impact of participation in HFG programmes on food security. Additionally, the framework showed that perception of the HFG programme by households had a direct impact on their participation, which in turn influenced their household food security status. It is worth noting that perception did not directly influence the food security status of households (Abdulai and Huffman 2014; Ntow et al. 2006).

2.2 Empirical strategy

Before an individual participated in the HFG programme, he or she first gathered background information about the programme by consulting extension officers and learning from other farmers, as well as after participation (Genius et al. 2014). We denoted the production function of the HFG as:

$$y_i = f\left(K_i^v, l_i^w, G_i\right) \tag{1}$$

where y_i represented crop production; K_i^v was a vector of farm inputs such as weedicide, seed, fertiliser, and pesticides; l_i^w denoted irrigation water, given that South Africa

is one the driest countries in world (Department of Water Affairs 2013) and G_i represented an irrigation farming technology index. Crop production (y_i) contributed significantly to households' food production and income, which in turn reduced food insecurity. However, non-participants or individuals participating in the HFG programme for the first time may not have been able to precisely quantify the actual benefits they obtained from participating in the programme. In this paper, we assumed that individuals reduced their uncertainty about the HFG programme by consulting extension officers and other participating farmers. Therefore, in our theoretical framework, we assumed that individuals' decisions whether or not to participate in the HFG programme were informed by their expectations about the contribution of the programme to their food production and security.

Based on this assumption, we denoted the net benefit that an individual i derived from participating in the HFG programme by ϖ_H and the net benefit from non-participation as ϖ_{NH}. An individual was expected to participate in the HFG programme if the utility derived from it in terms of reduction in food insecurity exceeded that of non-participation ($\varpi_H > \varpi_{NH}$). This translated into a binary choice, which was examined using a binary choice model. The two choice scenarios are represented as:

$$\varpi_H = X\beta_{H_i} + \varepsilon_{H_i} \tag{2}$$

$$\varpi_{iNH} = X\beta_{iNH} + \varepsilon_{iNH} \tag{3}$$

where X_i was a vector of socioeconomic, institutional and programme characteristics; β_H and β_{NH} were parameters to be estimated; and ε_{Hi} and ε_{NHi} were random disturbance

terms. The actual contribution of the programme to food security was not known to the researcher. However, the characteristics of participants and the programme itself were known during the survey. We represented the contribution of the HFG programme to food security by a binary dependent variable Y_i^*. Y_i^* was expressed as a function of the observed characteristics vector X_i. The observed characteristics were represented by Z. The latent model was specified as:

$$Y_i^* = \delta' Z_i + \mu_i, \quad Y_i = 1 \left[Y_i^* > 0 \right] \tag{4}$$

where Y_i was a binary dependent variable that equaled 1 for individuals who participated in the HFG programme, and zero otherwise. δ was a vector of parameters to be estimated. μ was the error term with zero mean and constant variance. Z consisted of factors such as an individual's age, educational level, gender, extension, market access and perception. However, Koundouri et al. (2006), and Abdulai and Huffman (2014) stated that there are endogeneity problems associated with explanatory variables such as extension visits and non-farm work. Hence, we addressed the potential endogeneity problem by expressing extension visits and non-farm work as functions of all other exogenous variables in the participation eq. (4), plus a set of instruments (Koundouri et al. 2006). This was specified as:

$$Pe_i = \lambda' X_i + \tau K_i + \xi_i \tag{5}$$

where Pe_i was a vector of extension contacts and non-farm work, X is as defined above, and K_i represents the set of instruments that is correlated with the endogenous variables. It is worth noting that the vector of instruments should not be correlated with the error term (μ) in eq. (4) and was not included in the estimation of the participation eq. (4). The participation equation was then specified as:

$$Y_i^* = \beta' X_i + \hbar Pe_i + T_i + v_i \tag{6}$$

where X_i was as defined above, Pe_i was a vector of observed extension contacts and non-farm work and T_i denoted a vector of residual terms obtained from the first-stage estimation of eq. (5).

Since individuals take into consideration the expected outcome of their choice of participation in an HFG programme, their choice of programme should be considered when analysing the impact of the programme on food security in order to avoid a selectivity effect (Pitt 1983). The selectivity effect will cause individuals, whose food security statuses are below average, to stop participating in the HFG programme, given the characteristics of the programme and fixed factors. This will lead to truncation of the distribution of observed benefits arising from the HFG programme. Theoretically, this occurs when the error terms of the participation (μ) and outcome equation (ε) are correlated ($corr(\mu, \varepsilon) = \rho$). This is usually caused by unobserved factors. When the unobserved

factors are determined, policy interventions can be implemented to deal with them, while promoting individuals' participation in the programme with the aim of improving the food security status of the people.

According to Abdulai and Huffman (2014), when the unobserved factors are not captured in estimations, ordinary least estimation procedure will yield biased estimates. Attributing food insecurity among participants to participation in the HFG programme is difficult in cross-sectional surveys since there is no information on counterfactual effects (Dehejia and Wahba 2002). Nonetheless, methods such as the Heckman two-stage estimation and instrumental variable approach have been used to address selection bias, particularly when the correlation between the error terms is greater than zero. However, this approach depends on the restrictive assumption of normally distributed errors, whereas there is also difficulty in finding and identifying instruments in the approach (Jalan and Ravallion 2003; Donkor et al. 2016a).

Based on the above limitations, a propensity score matching approach is regarded as one of the methods for assessing the impact of technology adoption or development intervention in situations where self-selection bias is a problem (Amare et al. 2012). The propensity score estimation procedure stabilises the observed distributions of covariates across the group of participants and non-participants. However, it does not account for selection bias that results from unobservable factors. Therefore, an endogenous switching regression model is appropriate, since it addresses the weakness of the propensity score matching (PSM) technique (Lee 1982).

2.2.1 The endogenous switching regression (ESR) model

The endogenous switching regression model accounts for unobserved variables by considering selectivity as an omitted variable problem (Heckman 1979). Since the food security status in our study was observed for both participants and non-participants, the switching regression model categorised individuals into HFG programme participants and non-participants in order to capture the differential response of the two sub-samples. If an individual chose to participate in the HFG programme, the observed contribution to food security took the form:

$$\psi_{Hi} = X_i' \beta_H + \varepsilon_{NHi}, \quad if \ Y_i = 1 \tag{7}$$

$$\Psi_{NH} = X_i' \beta_{NH} + \varepsilon_{NH}, \quad if \ Y_i = 0 \tag{8}$$

where Ψ_H and Ψ_{NH} were the outcome variables for the HFG programme participants and non-participants, respectively. The vectors β in eqs. (7 & 8) and δ in eq. (4) were associated parameters to be estimated. However, it must be emphasised that variables in vectors X in eqs. (7 & 8) and Z in eq. (4) may have overlapped, and that proper identification required that at

least one variable in Z did not appear in X. In such instances, self-selection into the participant or non-participant categories may have resulted in nonzero covariance between the error terms of the participation decision equation and the outcome equation. Therefore, the error terms μ, ε_{Hi} and ε_{NHi} were assumed to have a trivariate normal distribution with mean vector zero and the following covariance matrix:

$$\text{cov}(\varepsilon_H, \varepsilon_{NH}, \mu) = \sum = \begin{bmatrix} \sigma^2_{\varepsilon_H} & \sigma_{\varepsilon H\varepsilon NH} & \sigma_{\varepsilon H\mu} \\ \sigma_{\varepsilon H\varepsilon NH} & \sigma^2_{\varepsilon_{NH}} & \sigma_{\varepsilon NH\mu} \\ \sigma_{\varepsilon H\mu} & \sigma_{\varepsilon NH\mu} & \sigma^2_{\mu} \end{bmatrix} \quad (9)$$

w h e r e $\text{var}(\varepsilon_H) = \sigma^2_{\varepsilon_H}$; $\text{var}(\varepsilon_{NH}) = \sigma^2_{\varepsilon_{NH}}$, $\text{var}(\mu) = \sigma^2_{\mu}$; $\text{cov}(\varepsilon_H, \varepsilon_{NH}) = \sigma_{\varepsilon H\varepsilon NH}$; $\text{cov}(\varepsilon_H, \mu) = \sigma_{\varepsilon H\mu}$ and $\text{cov}(\varepsilon_{NH\mu}) = \sigma_{\varepsilon NH\mu}$. Under this condition, the ε_{Hi} and ε_{NHi} in eq. (4) had non-zero expected values, which were conditional on the sample selection criterion. Hence, Ordinary least square (OLS) estimates of β_H and β_{NH} were affected by sample selection bias (Lee 1982). As a result of that, Johnson and Kotz (1970) argued that the error terms should be truncated and these are given as:

$$E(\varepsilon_{NH}/Y = 0) = E(\varepsilon_{NH}/\mu \leq -x'\lambda)$$
$$= \sigma_{\varepsilon NH\mu} \frac{-\phi(x'\lambda/\theta)}{1 - \vartheta(x'\lambda/\theta)} = \sigma_{\varepsilon NH\mu}\gamma_{NH} \quad (10)$$

$$E(\varepsilon_H/Y = 1) = E(\varepsilon_H/\mu > -x'\lambda) = \sigma_{\varepsilon H\mu} \frac{-\phi(x'\lambda/\theta)}{\vartheta(x'\lambda/\theta)}$$
$$= \sigma_{\varepsilon H\mu}\gamma_H \quad (11)$$

where ϕ and ϑ denote the probability density and cumulative distribution functions, respectively; γ_H and γ_{NH} were inverse Mills ratios of ϕ and ϑ evaluated at $x'\lambda$. Inverse Mills ratios were added to eq. (4) to cater for bias in selection.

The endogenous switching regression model was estimated in two stages simultaneously to use a full information maximum likelihood estimation procedure in order to avoid a heteroskedasticity problem (Lokshin and Sajaia 2004). Thus, participation in the HFG programme and outcome (food security) equations were estimated simultaneously. A probit model was first estimated to determine the selectivity terms (γ_H, γ_{NH}). The signs and significance of the correlation coefficients (ρ) from the simultaneous estimations were very relevant. Endogenous switching is observed when either $\rho_{H\mu}(\sigma_{\varepsilon H\mu}/\sigma_{\varepsilon H}\sigma_{\mu})$ or $\rho_{NH\mu}(\sigma_{\varepsilon NH\mu}/\sigma_{\varepsilon NH}\sigma_{\mu})$ is statistically significant. Negative selection bias occurs when $\rho > 0$, implying that individuals whose food security statuses are below average are more likely to participate in the HFG programme. If $\rho < 0$, then there is positive selection bias, indicating that individuals whose food security statuses are above average will be more likely to participate in the HFG programme. The endogenous switching regression allowed the comparison of the actual expected outcomes of participants (12)

and non-participants (13), and to examine the counterfactual imaginary scenarios that the non-participants did participate (13) and that the participants did not participate (15) as follows:

$$E(\psi_H/y = 1) = X_1\beta_h + \sigma_{\varepsilon H\mu}\gamma_H \quad (12)$$

$$E(\psi_{NH}/y = 0) = X_0\beta_{NH} + \sigma_{\varepsilon NH\mu}\gamma_{NH} \quad (13)$$

$$E(\Psi_{NH}/y = 1) = X_1\beta_{NH} + \sigma_{\varepsilon NH\mu}\gamma_H \quad (14)$$

$$E(\Psi_H/y = 0) = X_0\beta_H + \sigma_{\varepsilon NH\mu}\gamma_H \quad (15)$$

The difference between eqs. (11) and (14) gives the average treatment effect on the treated (ATT) whereas the difference between eqs. (12) and (13) is the average treatment effect on the non-participants of HFG programmes (Donkor et al. 2016b). Note that the propensity score matching was used as a robust check to complement the endogenous switching regression. Mare and Winship (1978) and Lokshin and Sajaia (2004) posit that endogenous switching regression account for both observable and unobservable factors, while PSM addresses only observable factors. Moreover, Ma and Abdulai (2016) indicated that if at least one of the selectivity correction terms $(\gamma_H \& \gamma_{NH})$ is statistically significant, it implies there is selection bias that results from unobservable factors. In such a situation, the ESR model is appropriate for quantifying the causal effect of participation in HFG programmes. In contrast, when none of the selectivity correction terms is significant, it signifies the absence of selection bias from unobservable factors, and therefore, the PSM method is used to determine the causal effect related to the participation decision.

2.2.2 The propensity score matching (PSM) technique

The PSM matching technique compares the outcomes of HFG programme participants (treated) and non-participants (control). Observed characteristics of the treated and control groups were similar in order to minimise bias, which may have occurred if the two groups were entirely dissimilar (Dehejia and Wahba 2002). We first generated the propensity score of those participating in the HFG programme using a probit model. Second, the average treatment effect on the treated (ATT), based on the predicted propensity scores (Pr(X)), was estimated. The propensity score matching was specified as:

$$\Pr(X_1) = \Pr(Y_1 = 1|Z_1) = E(Y_1|Z_1) \quad (16)$$

where $Y_1 = \{0, 1\}$ gives an indication whether the individual participated in the HFG programme and Z_1 represented the characteristics of the programme. The average treatment effect of the treated (ATT), ψ^{PSM}_{ATT}, was specified as:

$$\psi_{ATT}^{PSM} = E\left[\psi_{H_i}|Y=1, \Pr(X)\right] - E\left[\psi_{NH_i}|Y=0, \Pr(X)|Y=1\right]$$

$$(17)$$

Average treatment effect on the treated in this study was estimated using propensity score matching (PSM). The nearest neighbour matching (NNM), kernel-based matching (KBM) and Radius methods of the PSM were employed to estimate the average treatment effect on the treated (ATT), because these methods were commonly used in the recent literature (Donkor et al. 2016b; Ma and Abdulai 2016). The endogenous switching regression (ESR) and propensity score matching (PSM) modelling approaches have been employed in recent literature to evaluate determinants and impacts of marketing contracts on net returns of apple farmers in China (Ma and Abdulai 2016). Amare et al. (2012) employed these methods to assess the welfare impacts of a maize-pigeonpea intensification programme in Tanzania. An endogenous switching regression was applied to assess the adoption and impact of soil and water conservation technology on yield and net returns. Similarly, these methods were employed by Donkor et al. (2016a, 2016b) to assess the impact of agricultural extension service on adoption of chemical fertilizer and its implications for rice productivity and development in Ghana as well as the impact of row-planting adoption on productivity of rice farming in Northern Ghana.

2.3 Data description

A multi-stage sampling technique was employed in this study. In the first stage, Gauteng province was chosen, because it was among the provinces that had benefited from the HFG programme. The second stage involved random selection of five municipalities in the province using balloting. The selected municipalities included Johannesburg, Tshwane, Ekurhuleni, West Rand and Sedibeng. Seventy-seven households were randomly chosen from Johannesburg, 78 from Tshwane, 103 from West Rand, 131 from Ekurhuleni, and 111 from Sedibeng, based on rural household populations in each municipality. In total, 500 rural farmers were selected, comprising 234 participants of the HFG programme and 266 non-participants. The survey data were collected in 2015 from the rural households using a structured questionnaire. The first part of the questionnaire solicited information regarding yield, revenue, costs, the HFG programme, asset endowments, and institutional, farm and socioeconomic characteristics related to the households. The second part captured information on household food security.

The Household Food Insecurity Access Scale (HFIAS), developed by the Food and Nutrition Technical Assistance Project (FANTA), was employed (Coates et al. 2007). This scale was used, because it is a simple and user-friendly method for assessing the impacts of developmental programmes on the access component of household food insecurity (Coates

et al. 2007). The HFIAS was also employed because we wanted to measure the degree of food insecurity as a continuous variable for analytical purposes. An HFIAS score was calculated for each household based on answers to nine 'frequency of occurrence' questions. The higher the score, the more food insecure the household was. The resulting data were analysed using SPSS 21 and Stata 13. Prior to the empirical estimations, we estimated mean differences between the summary characteristics for participants and non-participants for policy purposes. Hence, the results are presented for both participants and non-participants.

3 Results and discussion

3.1 Descriptive and summary characteristics of HFG programme participants and non-participants

Table 1 presents the summary characteristics of variables used in the analysis. Additionally, we estimated mean differences between HFG programme participants and non-participants. This was done to ascertain the difference in characteristics among the two categories of respondents. Mean Household Food Insecurity Access Scale (HFIAS) for participants was 0.99 with a minimum of 0.30 and maximum of 1.49, relative to non-participants whose mean HFIAS index was 1.66 with a minimum of 0.45 and a maximum of 3. The mean ages of HFG programme participants and non-participants were about 47 and 41, respectively. This finding concurs with that of Malope and Molapisane (2006) who found that the youth hardly participated in policy interventions (the homestead garden programme) and pursued different interests, because they did not see agriculture as a business in which one can survive. HFG programme participants on the average received 11 years of formal education, compared with non-participants with 14 years of formal education, with a significant mean difference of −3 at the 1% level, showing that educated people were less likely to participate in the programme. In South Africa, high educational level is correlated with lucrative jobs and therefore these educated people might have devoted their time to jobs rather than establishing a homestead garden. Msaki (2006) found that the level of education attained by the household related to human capital as well as the ability to cope with the processes of modern farm decision-making. Non-participants had significantly smaller household sizes compared with participants; participants, on average, had a household size of 5, whereas non-participants had 3, resulting in a significant mean difference of about 2 at the 1% level. Household size influenced adoption of the policy intervention programme and had important practical implications for labour availability, which acted as the basis for a household to decide whether or not to take part in the homestead garden programme (Nziane 2009). There were no significant mean

Table 1 Summary statistics of variables included in the analysis

Variable	Description	Participants N=234 (46.80%)			Non-participants N=266 (53.20%)			Mean difference
		Mean (SD)	Min	Max	Mean (SD)	Min	Max	
Outcome variable								
HFIAS score	Household Food Insecurity Access Score	0.99(0.79)	0.30	1.49	1.66(0.92)	0.45	3.00	−0.66***
Independent variables - Household characteristics								
Age	Age of farmer in years	47 (9.00)	25.00	68.00	41(8.11)	26.89	69.90	6***
Education	Years of formal education	11(3.11)	2.05	18.33	14(2.33)	4.99	19.78	−3***
Household size	Number of people in the household	5 (0.75)	1.00	6.77	3(0.70)	1.00	7.45	2***
Gender	1 if male, 0 otherwise	0.66(0.48)	0.00	1.00	0.62(0.50)	0.00	1.00	0.04
Off-farm activity	1 if farmer engages in off-farm activity	0.65(0.50)	0.00	1.00	0.70(0.30)	0.00	1.00	−0.05
Income	Monthly income (ZAR)	2872.56 (655.48)	1030.00	7080.00	6815.17 (159.89)	1890.99	15,542.00	−3942.16***
Farm characteristics								
Land size	Size of farm land (Ha)	0.72 (0.57)	0.45	2.85	0.57(0.19)	0.25	2.01	0.15
Distance	Distance from home to market (km)	3.49(0.12)	0.55	7.55	4.06(0.97)	0.61	8.95	−0.57
Market access	1 if farmer has access to market, 0 otherwise	0.56(0.49)	0.00	1.00	0.48(0.27)	0.00	1.00	0.08
Hired labour	1 if farmer employed hired labour, 0 otherwise	0.69 (0.54)	0.00	1.00	0.58(0.32)	0.00	1.00	0.11
Irrigation access	1 if farmer has access to irrigation system, 0 otherwise	0.40(0.49)	0.00	1.00	0.08(0.26)	0.00	1.00	0.32***
Fertilizer use	1 if farmer uses fertilizer, 0 otherwise	0.61(0.46)	0.00	1.00	0.32(0.42)	0.00	1.00	0.29***
Institutional characteristics								
Extension	1 if farmer has access to extension services, 0 otherwise	0.77 (0.42)	0.00	1.00	0.33(0.47)	0.00	1.00	0.43***
Credit access	1 if farmer has access to formal credit, 0 otherwise	0.52(0.12)	0.00	1.00	0.69 (0.32)	0.00	1.00	−0.17**
Support	1 farmer received other government support, 0 otherwise	0.89(0.43)	0.00	1.00	0.23(0.11)	0.00	1.00	0.66***
FBO	1 if farmer belongs to farmers organization,0 otherwise	0.85(0.21)	0.00	1.00	0.50 (0.09)	0.00	1.00	0.35***
Household assets								
Livestock	1 if farmer owns livestock, 0 otherwise	0.61(0.49)	0.00	1.00	0.69 (0.30)	0.00	1.00	−0.08
Livestock value	Value of livestock in ZAR	28,172.61 (255.48)	15,007.00	31,500.11	27,815.17 (359.89)	15,123.44	29,675.98	357.43
Implements value	Value of farm implements in ZAR	22,833.83 (311.34)	18,562.32	33,672.45	31,088.89 (381.09)	17,005.10	37,785.89	−8255.06***
Perception Index	Farmers perception about homestead garden program (1 = Poor; 2 = satisfactory; 3 = Good)	2.89	1.98	3.00	1.23	1.08	2.05	1.66***

Authors calculation, 2016 *'**'*** denote 10%, 5% and 1% significant levels respectively. Values in brackets are standard deviations (SD)

differences between gender among participants and non-participants, as males constituted 66% and 62% of participants and non-participants, respectively. About 65% of participants participated in off-farm activity, compared with 70% of non-participants. The mean monthly income of programme participants and non-participants were significantly different at about ZAR 2872.56 and ZAR 6815.17, respectively (ZAR = South African Currency, Rand: 1 ZAR = about 0.073 US dollars),

HFG programme participants had about 0.15 ha of land more than non-participants. The average distance from home to market was 3.49 and 4.06 km, for participants and non-participants, respectively. About 56% of participants had access to markets, compared with 48% of non-participants. Sixty-nine percent of the participants used hired labour, compared with 58% of non-participants. Mothupi (2014) found it significant to provide homestead garden participants with the most current market information, procedures and rules. On average, 40% of participants had access to irrigation, relative to 8% for non-participants, giving a highly significant mean difference of 0.32 at the 1% level. Home gardening and access to irrigation are crucial components of agriculture. Access to irrigation allows homestead garden participants to increase their production and income, enhances opportunities for diversifying their income base and reduces vulnerability caused by the seasonality of agricultural production as well as external shocks (Hussain and Hanjra 2004).

We found that 61% of HFG programme participants used nitrogen fertilisers, relative to 32% of non-participants. This concurs with Galhena (2012) who found that fertilizer was commonly used by home gardeners. About 77% of HFG programme participants had access to extension services, relative to 33% of non-participants, with a significant mean difference of 0.43. On average, 52% of the participants had access to credit, relative to 69% of the non-participants, giving a significant mean difference of −0.17, suggesting that non-participants had greater access to formal credit. About 89% of the HFG programme participants had access to alternative government support in the form of social grants, relative to 23% of non-participants.

Most (85%) participants belonged to farmer associations, compared with 50% of non-participants. The significant mean difference indicated that HFG programme participation facilitated a farmer's social capital. There was no significant mean difference relating to livestock ownership. The results showed that 61% of participants and 69% of non-participants owned livestock. HFG programme participants and non-participants owned livestock valued at ZAR 28,172 and ZAR 27,815, respectively. In terms of value for farm implements, non-participants had ZAR 8255 more implements than participants.

The perception index for HFG programme participation was high (2.89) among participants, compared with non-participants (1.23). This suggested that participants had more positive attitudes towards the benefits of HFG programmes compared with non-participants. Swanepoel (2007) highlighted that policy intervention programmes (homestead garden programmes) and implementation thereof should take into account perceptions of the participants and their involvement. The household food insecurity access score for HFG programme participants was 0.99, compared with 1.66 for non-participants. The significant mean difference of −0.66 meant that food insecurity among participants was lower, compared with non-participants. Faber et al. (2011) and Khanyile (2012) found that a homestead garden as a livelihood strategy was able to lessen people's vulnerability and insecurity. As a policy intervention, homestead gardens are recognised as a means of addressing food insecurity and alleviating poverty in developing countries.

3.2 Food security status among HFG programme participants and non-participants

The food security status among participants and non-participants of the HFG programme is presented in Table 2. The results showed that 50.6% (253) of the respondents were food secure, compared with 49.4% (247) who were not food secure. This differs somewhat from the findings of Rudolph (2012) who showed that only 44% of households in Johannesburg were food secure. Among the food-secure respondents, 62.5% of them were participants in the HFG programme, while the remaining respondents were non-participants. However, 32.5% of the participants were food insecure, while 64.3% of non-participants were also food insecure.

The extent of food insecurity results showed that 38.9% of all respondents were moderately food insecure, 37.7% were severely food insecure, and 23.5% were mildly food insecure. However, only 9.8% of the HFG programme participants were severely food insecure, 10.7% moderately food insecure and 12.0% were mildly food insecure. About 11.3%, 26.7% and 26.3% of non-participants were mildly, moderately and severely food insecure, respectively. The high proportion of moderately and severely food insecure respondents among non-participants is a major issue of concern and needs to be given much attention by policy makers in the Gauteng province. These results were consistent with those of May and Carter (2009) who found that more than 20% of South African households had severely inadequate access to food.

The summary statistics of the household food insecurity access score (HFIAS) are presented in Table 3. The overall average HFIAS score for the respondents was 1.54, which confirmed the occurrence of food insecurity among rural households in the Gauteng province. The overall HFIAS score was estimated by summing the scores for the individual HFIAS questions over the total number of questions. An HFIAS score was calculated for each household, based on answers to the nine 'frequency of occurrence' questions in

Table 2 Food security status among participant and non-participant of homestead garden programme

Variable	Category	Participant (n = 234)	Non-participants (N = 266)	Total N = 500
Food security levels	Food secure	158	95	253 (50.60%)
	Food insecure	76	171	247 (49.40%)
Extent of food insecurity	Mild	28	30	58 (23.48%)
	Moderate	25	71	96 (38.87%)
	Severe	23	70	93 (37.65%)

Authors calculation, 2016

Table 3. The higher the score, the more food insecure the household was. Specifically, the results indicated that 67.60% of the respondents worried about inadequate food in their households, while the remaining 32.4% did not worry about it. Among those who worried about inadequate food, 38.2% indicated that they often worried about inadequate food in the household.

The majority of the respondents (67.2%) were unable to eat their preferred foods, and this occurred often, as indicated by 223 (66.4%) out of the 336 respondents who were unable to eat their preferred foods. About 61.8% of the respondents indicated that they only ate a few kinds of foods and that this happened often. Also 77.0% of the respondents indicated that they ate foods they really did not want to eat and this occurred often. Similarly 59.8% of the respondents ate smaller meals and this also occurred often. Again, 62.8% of the respondents indicated that they ate fewer meals in a day, whereas 55.0% indicated that they had no food of any kind in the household. Furthermore, 46.6% of the respondents indicated that they went to sleep without food, and 44.0% went the whole day and night without food. This provided detailed information on the occurrence of food insecurity in the study area and hence the need for food security interventions such as HFGs.

However, it must be emphasised that the HFG was not the only source of food for respondents in the study area. Respondents relied on any other sources of food available to them and their food choices were not limited to what was harvested from the garden. In order not to decrease agro-biodiversity, participants in the programme were allowed to grow different crops of their choice in addition to what was provided in the programme package.

3.3 Determinants of households' participation in the HFG programme

The empirical results for the two-stage endogenous switching regression model estimated for HFG programme participation and its impact on household food insecurity are presented in Table 4. The results for the selection equation (column 2) represents the determinants of households' participation in the HFG programme and the estimates were interpreted as normal probit coefficients. Education was significantly different from zero and negative in the selection equation. This meant that as the education of the respondents increased, their willingness to participate in the HFG programme reduced, suggesting that less-

Table 3 Indicators of Household Food Insecurity Access Score (HFIAS)

Indicator	Yes	No	Incidence occurrence				HFIAS score
			Not (0)	Rarely (1)	Sometimes (2)	Often (3)	
1. Worry about inadequate food	**338**	162	162	51	96	191	1.63
2. Unable to eat preferred foods	**336**	164	164	39	74	223	1.71
3. Eat just few kinds of foods	**309**	191	191	45	78	198	1.59
4. Eat foods they really do not want to eat	**386**	114	114	28	81	277	2.04
5. Eat smaller meal	**299**	201	201	14	74	211	1.59
6. Eat fewer meals in a day	**314**	186	186	38	50	226	1.63
7. No food of any kind in the household	**275**	225	265	7	95	173	1.43
8. Go to sleep hungry	**233**	267	267	31	48	154	1.18
9. Go a whole day and night without eating	**220**	280	280	39	44	137	1.08
Overall HFIAS score							1.54

Authors calculation, 2016

Table 4 Endogenous switching regression estimates for homestead food garden programme participation and its impact on food insecurity (HFIAS score)

Variable	Selection[a]	Food insecurity (HFIAS)[b]	
		Participants	Non- Participants
Constant	−2.907(1.883)	−3.004**(1.193)	−1.375(1.848)
Age	−0.039(0.050)	−0.001(0.008)	−0.013(0.012)
Education	−0.318*(0.194)	−0.191***(0.037)	−0.310*** (0.117)
Household size	0.462(0.356)	0.048(0.111)	0.105(0.151)
Gender	1.587***(0.423)	0.128(0.173)	0.344(0.266)
Off-farm activity	−7.019 **(3.352)	−0.169***(0.055)	−0.408***(0.156)
Income	0.229***(0.082)	−0.150***(0.056)	−0.177***(0.068)
Land size	0.534*(0.291)	−0.039(0.057)	−0.025(0.114)
Distance	0.030*(0.018)	0.017**(0.007)	−0.021(0.024)
Market access	0.207(0.166)	−1.150***(0.059)	−0.408***(0.155)
Hired labour	−1.488(1.351)	−0.005(0.197)	1.025(0.367)
Irrigation access	0.899***(0.191)	−1.052***(0.102)	−1.803***(0.222)
Fertilizer use	0.534*(0.291)	−0.518**(0.255)	−0.398**(0.161)
Extension	0.985***(0.174)	−0.939**(0.389)	−0.628**(0.294)
Credit access	0.504***(0.168)	−0.562**(0.046)	−0.806***(0.128)
Support	0.854***(0.212)	−0.122***(0.012)	−0.132***(0.029)
FBO	1.024***(0.193)	−0.570***(0.126)	−0.118(0.077)
Livestock	2.004*(1.103)	−0.225(0.240)	−0.014(0.010)
Livestock value	−0.001(0.012)	−0.013**(0.005)	−1.139**(0.577)
Implements value	−0.649(0.413)	−1.872***(.346)	−2.653**(1.257)
Johannesburg	−0.678***(0.181)	0.166(0.110)	−1.013***(0.212)
West Rand	0.667*(0.381)	−1.142***(0.418)	−0.169(0.412)
Ekurhuleni	−0.676***(0.131)	−0.455***(0.130)	−0.430***(0.134)
Sedibeng	1.147***(0.155)	0.123(0.098)	−0.549***(0.153)
Perception	0.706***(0.151)		
Extension residual	−1.108 (0.929)		
Off-farm residual	−0.070(0.265)		
Diagnostic statistics			
LR test of independence	53.700 ***		
Log likelihood	−761.249		
Wald chi2	151.15		
Ln_{NH}			0.139***(0.051)
Ln_H	−0.562***(0.046)		
ρ_{NH}			0.005(0.197)
ρ_H	2.939***(0.389)		

Authors calculation, 2016. *, ** and *** indicates significance at 10%, 5% and 1% levels

[a] Dependent variable for the selection equation is participation in homestead food garden (1 if household participates in the programme, 0 otherwise

[b] Dependent variable for the outcome equation is food insecurity (HFIAS) index measured as a continuous variable

educated households were more likely to participate in the programme. This is contrary to the findings of Huffman (2001) who stated that education promotes participation by farmers in new and sustainable programmes.

The gender variable was found to be significant and positive, implying that males were more likely to participate in HFG programmes compared to females. This suggested that female farmers' participation in the programme needs to be given greater attention. We found that respondents who engaged in off-farm activities were less likely to participate in the HFG programme, as indicated by the significantly negative coefficient at the 5% level. This may be attributable to the fact that non-farm activities restricted the allocation of labour and time to work in the HFG. Income of households was

significantly different from zero and positive. This means that as the incomes of households increased, their willingness to participate in the programme also increased, all things being equal.

Households with extensive land were more likely to participate in the HFG programme. This was indicated by the significant coefficient for the land size variable. Distance to market impacted positively on households' decisions to participate in the HFG programme, as shown by the significantly positive coefficient of the distance variable. Households that had access to irrigation facilities were also more likely to participate in the HFG programme, all things being equal. This might have been because vegetable production in HFGs requires water, especially given the current changes in rainfall patterns attributable to climate variability. The adoption of chemical fertiliser positively influenced households' participation in the HFG programme. This was indicated by the significantly positive coefficient estimate for the fertiliser use variable, a result consistent with that of Abdoulaye and Sanders (2005).

Access to extension services was significantly different from zero, with a positive coefficient estimate. This suggested that farmers with extension contacts had a higher probability of participating in the HFG programme. This finding provides the rationale for improvement in the extension agent-to-farmer ratio, which is considered poor in Africa (Alam et al. 2012). Access to credit was statistically significant and positive, indicating that farmers who were not credit constrained were more likely to participate in HFG programmes, a result in accordance with those of Kassie et al. (2011). This emphasises the relevance of credit access in facilitating farmers' participation in livelihood improvement interventions. Households that received other support from the government besides the HFG programme, were more likely to participate in the programme, as shown by the highly significant coefficient for the support variable. Households in social networks with other farming households were more likely to participate in the HFG programme, as shown by the highly significant and positive coefficient for the social network variable. This supports the idea that farmers' social capital enhances information sharing, which tends to facilitate participation in sustainable farming practices and interventions (Bandiera and Rasul 2006).

Households who owned livestock were more likely to participate in the HFG programme. This might be attributable to the fact that these households had access to manure from the animals, which could be used to fertilise the vegetables and hence enhance their participation in vegetable production. In terms of location, we found that staying in the Johannesburg and Ekurhuleni districts reduced the probability of participating in the programme, as shown by the significantly negative coefficients. This might have been due to the more urbanised nature of the area, which limited land availability for homestead food gardening. However, staying in the West Rand and

Sedibeng districts increased the likelihood of participating in the HFG programme, relative to the Tshwane district.

Farmers' decisions to participate in the HFG programme were highly dependent on their perceptions of the benefits associated with the programme. This was shown by the highly significant and positive estimate for the perception variable, a finding consonant with that of Ntow et al. (2006). This meant that management and authorities of the HFG programmes can influence farmers' participation by creating a positive mental attitude among farmers concerning the programme.

3.4 Determinants of households' food insecurity among HFG programme participants and non-participants

The results of the determinants of food insecurity are presented in the third and fourth columns of Table 4. Among the personal and household characteristics, education had a significantly negative influence on the food insecurity status of both participants and non-participants of the HFG programme, reducing this by 0.191 and 0.310, respectively. This finding concurs with that of De Cock et al. (2013) who found that food insecurity was higher among uneducated households. The off-farm activity variable was highly significant and negative for both participants and non-participants. Household income was significantly different from zero and negative for both participants and non-participants. This suggested that an increase in a household's income reduced food insecurity by the respective coefficients for participants and non-participants, a result consistent with the report of UNWFP (2006), which indicated that income generation and production improved food security among households.

The distance to market variable was significant and positive for participants at the 5% level, the further the distance was from a participant's household to market, the higher that household's food insecurity was. Similarly, access to market significantly reduced food insecurity among participants and non-participants. The access to irrigation variable was significantly different from zero and negative for both participants and non-participants, indicating that access to irrigation facilities would have reduced household food insecurity by their respective coefficients, all things being equal. Access to extension services reduced food insecurity of both participating and non-participating households and was significant at the 5% level. Extension agents provide farmers with information regarding improved production and postharvest technologies, marketing and financing, which enhances their production and income, improving their food security status (Alam et al. 2012).

Access to credit had a significantly negative influence on the food insecurity of both participating and non-participating households. Access to government support in the form of a

social grant significantly reduced the household food insecurity of both participants and non-participants. The social network variable was significantly different from zero and negative for participating households at the 1% level, showing that participating households with social networks with other farmers were more likely to be food secure than those who did not have social networks. Households with more livestock were more likely to be food secure, as indicated by the significant and negative coefficient estimates for value of livestock for both participating and non-participating households at 5% level.

In terms of location, we found that staying in the Johannesburg district reduced food insecurity among non-participating households, whereas residing in the West Rand district reduced food insecurity among participating households, relative to the reference district of Tshwane. Similarly, residing in the Ekurhuleni district reduced food insecurity of both participating and non-participating households, while residing in the Sedibeng district only reduced food insecurity among non-participating households, relative to the Tshwane district. This implied that one's location significantly influenced his or her food security status, suggesting that food insecurity should be tackled from a district-specific viewpoint.

Moreover, the results indicated that the residuals of access to extension services and engagement in off-farm activities were statistically insignificant, suggesting that our estimations were consistent. Based on the significant chi-square statistic (53.70) for testing over-identification restriction, we did not reject the exclusion restriction that the instrumental variable (perception of HFG programme) affected participation only through extension access and off-farm activity variables. This concurs with the findings of Ma and Abdulai (2016). The significant covariance term for the participants (ρ_H) indicated that self-selection took place in households' participation in the HFG programme. This implies that participation in the HFG programme may have impacted differently on non-participants, had they decided to participate in the programme (Liu et al. 2002). The positive sign of (ρ_H) revealed the existence of negative selection bias, showing that households whose food security statuses were below average were more likely to participate in the HFG programme. This was not surprising, given that the programme aimed at reducing extreme poverty and food insecurity among households. Also,

the insignificant statistic ρ_{NH} showed that both participating and non-participating households, on average, faced similar food insecurity challenges without participating in the HFG programme.

3.5 Impact of the HFG programme on food insecurity: Endogenous switching regression and propensity score matching estimations

The significant covariance term (ρ_H) for HFG programme participants revealed the presence of selection bias, arising from unobserved factors. Therefore, there was the need to account for both observable and unobservable factors in order to attain unbiased treatment effects. Hence, we estimated the average effect on the treated (ATT) from the endogenous switching regression (ESR), which accounted for selection bias emanating from observed and unobserved factors (Table 5). Participation in the HFG programme reduced household food insecurity by 41.5%, when non-participants of the programme were treated as the control group, showing that promoting households' participation in the HFG programme reduces food insecurity.

The propensity score matching (PSM) technique was also employed to estimate the average treatment effect of HFG programme participation on food insecurity, given that there was no selection bias arising from unobservable factors, and the results are presented in Table 6. The results generally indicated that participation in the HFG programme exerted negative and a statistically significant impact on household food insecurity. Specifically, participation in the HFG programme significantly reduced household food insecurity by 11.02–40.2%, using the nearest neighbour, kernel-based and radius matching methods. The estimated propensity score presented in Appendix revealed that 86.1% of the sample observations were correctly predicted. The intuition drawn from the average treatment on the treated from the ESR and the PSM estimates demonstrated that without accounting for selection bias resulting from both observable and unobservable factors, HFG programme implementers and stakeholders underestimated the real impact of HFG programme participation on household food insecurity.

The study was not without limitations. It has to be noted that our sampled households were from the Gauteng province

Table 5 Average treatment effect of homestead food garden programme participation on food insecurity: Endogenous switching regression estimation

	Mean outcome		ATT	t-Value	% change
	Participants	Non-Participants			
Food insecurity(HFIAS)	0.993	1.698	−0.705***	−3.30	−41.52

Authors' calculation, 2016

*** indicates significance at 1% levels

Table 6 Average treatment effect of homestead food garden programme participation on food insecurity: Propensity score matching estimation

	Mean outcome		ATT	t-Value	% change
	Participants	Non-Participants			
Nearest neighbour matching (NNM)					
Food insecurity (HFIAS)	0.993	1.116	−0.123**	−2.62	−11.02
Kernel-based matching (KBM)					
Food insecurity (HFIAS)	0.993	1.217	−0.224**	−3.40	−18.41
Radius					
Food insecurity (HFIAS)	0.993	1.661	−0.668***	−11.11	−40.22

Authors' calculation, 2016

*, ** and *** indicates significance at 10%, 5% and 1% levels

only and did not include respondents from other provinces where the programme had been implemented (Eastern Cape, North West and KwaZulu-Natal). Hence, the external validity of our findings was limited given that the participation decision and impacts of the programme on households could differ from province to province. It is suggested that future research should consider similar impact assessments in other provinces where the HFG programme has been implemented in order to ascertain if the contribution of the programme to food security, as reported in this paper, is robust compared to the findings from the other provinces. This study focused only on food insecurity. Therefore, we suggest that future research examines the impact of the programme on household income since excess supply from the homestead garden is sold to generate income. Also, the HFG programme has not been implemented in all provinces, despite its potential benefits in reducing food insecurity, malnutrition and hunger. Therefore, stakeholders and implementers of the HFG programme should consider extending the programme to other provinces.

4 Conclusions

In line with the first objective of the study, we conclude that socioeconomic factors such as household income and being a male enhanced participation in the HFG programme, whereas education and engagement in off-farm activities impacted negatively on participation in the programme. Among farm or HFG characteristics, we conclude that factors such as land size, distance to market, access to irrigation facilities and adoption of fertiliser facilitated households' participation in the HFG programme. Regarding institutional factors, we conclude that access to extension services and credit, government support and farmers' association membership positively influenced households' participation in the HFG programme. Ownership of livestock enhanced participation in the programme. We also conclude that the locations of households, as well as their perception of the programme, influenced their participation.

In terms of impact of the programme on food insecurity among rural households, we conclude that participation in the HFG programme significantly reduced food insecurity in the Gauteng province. The majority of the food-secure households in the study area were participants of the HFG programme. This emphasises the need to encourage more households to participate in the programme and we recommend that government and policy makers should encourage rural households' participation. The empirical findings from the impact assessment demonstrated the existence of selection bias in households' participation in the HFG programme and that without accounting for selection bias, the real impact of the programme on food security will be incorrectly estimated. Therefore, we recommend that current and future impact evaluations of food security policy interventions should take into account selectivity effects arising from both observed and unobserved factors in order to attain unbiased and consistent estimates. This can be done by employing empirical approaches such as endogenous switching regression, which accounts for selectivity effects.

In terms of determinants of food insecurity among participating and non-participating households, it was concluded that food insecurity among participating and non-participating households was significantly reduced by factors such as education, household income, participation in off-farm activities, access to market, irrigation, extension, and credit, adoption of fertiliser, and government support, as well as the value of livestock and farm implements. Precisely, policies that enhance households' access to credit, extension services, and irrigation facilities, as well as the promotion of fertiliser use and ownership of livestock, should be promoted by policy makers and programme implementers since these facilitate households' participation in the HFG programme, which in turn improves household food security status.

Compliance with ethical standards

Appendix

Table 7 Propensity score estimates for participation in homestead food garden programme

Dependent variable	Participation (1 if household participates in the programme, 0 otherwise)		
Explanatory variables	Coefficient	Standard error	z-values
Constant	−1.997	1.883	1.06
Age	−0.059	0.050	1.18
Education	−1.018**	0.394	2.58
Household size	1.462**	0.656	2.23
Gender	0.987**	0.423	2.33
Off-farm activity	−5.332 **	2.672	2.00
Income	0.276**	0.112	2.46
Land size	0.553**	0.281	1.97
Distance	0.130	0.118	1.10
Market access	0.247	0.189	1.31
Hired labour	−1.088	1.321	0.82
Irrigation access	0.788***	0.241	3.27
Fertilizer use	0.434	0.291	1.49
Extension	0.886***	0.143	6.20
Credit access	0.594***	0.108	5.50
Support	0.775***	0.113	6.86
FBO	1.027***	0.193	5.32
Livestock	2.134*	1.223	1.74
Livestock value	−0.021	0.112	0.19
Implements value	−0.479	0.411	1.17
Johannesburg	−0.587***	0.161	3.65
West Rand	0.634*	0.331	1.92
Ekurhuleni	−0.566***	0.121	4.68
Sedibeng	0.947***	0.125	7.58
Diagnostic statistics			
Pseudo-R^2	0.454		
Log-Log likelihood	−126.68		
Correctly classified	86.07%		
Observations	500		

Authors' calculation, 2015. *, ** and *** indicates significance at 10%, 5% and 1% levels

References

Abdoulaye, T., & Sanders, J. H. (2005). Stages and determinants of fertiliser use in semiarid African agriculture: The Niger experience. *Journal of Agricultural Economics, 32*, 167–179.

Abdulai, A., & Huffman, W. E. (2014). The adoption and impact of soil and water conservation technology: an endogenous switching regression application. *Land Economics, 90*(1), 26–43.

Alam, A., Kobayashi, H., Matsumura, I., & Esham, M. (2012). Factors influencing farmers' participation in participatory irrigation management: A comparative study of two irrigation systems in northern areas of Pakistan. *Mediterranean Journal of Social Sciences, 3*(9), 275–284.

Amare, M., Asfaw, S., & Bekele, S. (2012). Welfare impacts of maize-pigeonpea intensification in Tanzania. *Agricultural Economics, 43*, 27–43.

Bandiera, O., & Rasul, I. (2006). Social networks and technology adoption in northern Mozambique. *Economic Journal, 116*(514), 869–902.

Bushamuka, V. N., de Pee, S., Talukder, A., Kiess, L., Panagides, D., Taher, A., & Bloem, M. (2005). Impact of a homestead gardening program on household food security and empowerment of women in Bangladesh. *Food Nutrition Bulletin, 26*(1), 17–25.

Coates, J., Swindale, A., & Bilinsky, P. (2007). *Household food insecurity access scale (HFIAS) for measurement of food access: indicator guide (Version 3)*. Food and Nutrition Technical Assistance Project (FANTA), Academy for Educational Development, Washington, DC.

De Cock, N., D'Haese, M. D., Vink, N., van Rooyen, C. J., Staelens, L., Schönfeldt, H. C., & D'Haese, L. (2013). Food security in rural areas of Limpopo province, South Africa. *Food security, 5*(2), 269–282.

Dehejia, R. H., & Wahba, S. (2002). Propensity score–matching methods for nonexperimental causal studies. *Review of Economics and Statistics, 84*, 151–161.

Department of Agriculture, Conservation and Environment (DACE). (2002). *Standard of Operation Procedures*. Johannesburg. Available at: http://www.gdard.gpg.gov.za/Documents1/Homestead foodgarden.pdf. Accessed 28 Oct 2016.

Department of Agriculture, Forestry and Fisheries (DAFF). (2014). The national policy on food and nutrition security for the Republic of South Africa. Report No. 637. Available at: https://www.gov.za/sites/default/files/37915_gon637.pdf. Accessed 24 Oct 2016.

Department of Water Affairs (2013). *Strategic overview of the water sector in South Africa*, Pretoria: Department of Water Affairs. Available at: http://nepadwatercoe.org/wp-content/uploads/Strategic-Overview-of-the-Water-Sector-in-South-Africa-2013.pdf. Accessed 15 Jan 2017.

Du Toit, D. C., Ramonyai, M. D., Lubbe, P. A., & Ntushelo, V. (2011). *Food Security in South Africa*. Department of agriculture, forestry and Fisheries (DAFF), South Africa.

Donkor, E., Owusu, V., Owusu-Sekyere, E., & Jordaan, H. (2016a). Impact of agricultural extension service on adoption of chemical fertilizer: Implications for rice productivity and development in Ghana. *NJAS, Wageningen Journal of Life Sciences, 79*, 41–49.

Donkor, E., Owusu-Enoch, E., Owusu, E., & Jordaan, H. (2016b). Impact of row-planting adoption on productivity of rice farming in Northern Ghana. *Review of Agricultural and Applied Economics, 19*(2), 19–28.

Faber, M., Venter, S. L., & Benade, A. S. (2002). Increased vitamin A intake in children aged 2-5 years through targeted home-gardens in a rural South African community. *Public Health Nutrition, 5*(1), 11–16.

Faber, M., Witten, C., & Drimie, S. (2011). Community-based agricultural interventions in the context of food and nutrition security in South Africa. *South African Journal of Clinical Nutrition, 24*(1), 21–30.

Food and Agricultural Organization (FAO). (2009). *Global Agriculture towards 2050*. FAO: Rome.

Galhena, D.H. (2012). Home garden for improved food security and enhance livelihood in Northern Sir Lanka. PhD Thesis, Michigan State University.

Galhena, D. H., Freed, R., & Maredia, K. M. (2013). Home gardens: a promising approach to enhance household food security and well-being. *Agriculture and food security, 2*(8), 1–13.

Gauteng Agricultural Development Strategy (GADS). (2006). Department of Agriculture, Conservation and Environment. Johannesburg, Republic of South Africa. Available at: http://www.polity.org.za/article/mosunkutu-gauteng-agriculture-conservation-and-environment-prov-budgetvote-06062006-2006-06-06. Accessed 20 Oct 2016.

Genius, M., Koundouri, P., Nauges, C., & Tzouvelekas, V. (2014). Information transmission in irrigation technology adoption and diffusion: Social learning, extension services, and spatial effects. *American Journal of Agricultural Economics, 96*(1), 328–344.

Heckman, J. J. (1979). Sample selection bias as a specification error. *Econometrica, 47*(1), 153–161.

Huffman, W. E. (2001). Human capital: Education and agriculture. In B. L. Gardner & G. C. Rausser (Eds.), *Handbook of Agricultural Economics 1B*. Amsterdam: Elsevier Science.

Hussain, I., & Hanjra, M. A. (2004). Irrigation and poverty Alleviation: Review of empirical evidence. *Irrigation and Drainage, 53*(1), 1–15.

Jalan, J., & Ravallion, M. (2003). Estimating benefit incidence for an anti-poverty program using propensity score matching. *Journal of Business and Economic Statistics, 21*(1), 19–30.

Johnson, N. L., & Kotz, S. (1970). *Distributions in Statistics: Continuous Univariate Distribution* Vols. 1 and 2. Boston: Houghton Mifflin.

Kassie, M., Bekele, S., & Muricho, G. (2011). Agricultural technology, crop income and poverty alleviation in Uganda. *World Development, 39*(10), 1784–1795.

Khanyile, N.K. (2012). Food security at Qhubeni: A case Study of the One home one garden campaign as a Poverty Alleviation Strategy. University of KwaZulu-Natal, South Africa.

Koundouri, P., Nauges, C., & Tzouvelekas, V. (2006). Technology Adoption under Production Uncertainty: Theory and Application to Irrigation Technology. *American Journal of Agricultural Economics, 88*, 657–670.

Lee, L. (1982). Some approaches to the correction of selectivity bias. *Review of Economic Studies, 49*(3), 355–372.

Liu, J., Meinzen-Dick, R., Qian, K., Zhang, L., & Jiang, L. (2002). The impact of irrigation management transfer on household production in central China. *China Economic Quarterly, 17*, 465–480.

Lokshin, M., & Sajaia, Z. (2004). Maximum likelihood estimation of endogenous switching regression models. *Stata Journal, 4*(3), 282–289.

Ma, W., & Abdulai, A. (2016). Linking apple farmers to markets: Determinants and impacts of marketing contracts in China. *China Agricultural Economic Review, 8*(1), 2–21.

Malope, P., & Molapisane, K. R. (2006). Poverty reduction trough alternative livelihoods in Botswana's desert margins. *South African Journal of Agricultural Extension, 35*(1), 37–50.

Mare, R.B., & Winship, C. (1987). Endogenous switching models for the causes and effects of discrete variables. CDE Working Paper 87-32. Available at: https://www.ssc.wisc.edu/cde/cdewp/87-32.pdf. Accessed 23 Oct 2016.

May, J., & Carter, M. (2009). *Agriculture: Analysis of the NIDS Wave 1 dataset*. Discussion paper no.6. University of Cape Town: National Income Dynamics Study (NIDS). PP.1–3.

Msaki, M. M. (2006). Measuring household food security using food intake indicators in rural KwaZulu-Natal. University of KwaZulu-Natal, Pietermaritzburg, South Africa.

Maroyi, A. (2009). Traditional home gardens and rural livelihoods in Nhema, Zimbabwe: A sustainable agroforestry system. *International Journal of Sustainable Development World Ecology, 16*(1), 1–8.

Moskow, A.L. (1996). The contributions of urban agriculture in Havana, Cuba to individual control and community enhancement. Unpublished M.A. thesis, University of California, Davis.

Mothupi, R. (2014). *Entrepreneurial activities among HFGing and irrigation crop farmers in the Northern Cape province, South Africa*. South Africa: MSc dissertation.

Nkosi, S., Gumbo, T., Kroll, F., & Rudolph, M. (2014). Community gardens as a form of urban household food and income supplements in African cities: Experiences in Hammanskraal, Pretoria. Briefing No. 112. South Africa: Africa Institute of South Africa.

Ntow, W. J., Gijzen, H. J., Kelderman, P., & Drechsel, P. (2006). Farmer perceptions and pesticide use practices in vegetable production in Ghana. *Pest Management Science, 62*(4), 356–365.

Nziane, E.M. (2009). Community development projects and livelihood in Limpopo Province of South Africa. MSc dissertation, University of North West, South Africa.

Pienaar, L., & Fintel, D.V. (2013). *Hunger in the former apartheid homelands: Determinants of converging food security 100 years after the 1913 Land* Act. Economic Working Papers: 26/13 of the department of economics and the bureau for economic research at the University of Stellenbosch.

Pitt, M. M. (1983). Farm-level fertilizer demand in java: a meta-production function approach. *American Journal of Agricultural Economics, 65*(3), 502–508.

Rudolph, M. (2012). *The state of food insecurity in Johannesburg*. Urban food series No. 12. Kingstown.

Sasson, A. (2012). Food security for Africa: an urgent global challenge. *Agriculture and Food Security, 1*(12), 1–16.

Schreinemachers, P., Patalagsa, M. A., & Nasir Uddin, M. D. (2016). Impact and cost-effectiveness of women's training in home gardening and nutrition in Bangladesh. *Journal of Development Effectiveness, 8*(4), 473–488.

Swanepoel, H. (2007). Putting Plans into Action, 3rd edition. Cape Town. Juta.

Talukder, A., Kiess, L., Huq, N., de Pee, S., Darnton-Hill, I., & Bloem, M. W. (2000). Increasing the production and consumption of vitamin A–rich fruits and vegetables: lessons learned in taking the Bangladesh homestead gardening programme to a national scale. *Food Nutrition Bulletin, 21*(2), 165–172.

Tho Seeth, H., Chachnov, S., & Surinov, A. (1998). Russian poverty: muddling through economic transition with garden plots. *World Development, 26*(9), 1611–1623.

Trefry, A., Parkins, J. R., & Cundill, G. (2014). Culture and food security: a case study of homestead food production in South Africa. *Food security, 6*(4), 555–565.

United Nation World Food Program (UNWFP). (2006). World Hunger Series 2006: Hunger and Learning. Stanford University Press. Available at: https://www.unicef.org/lac/World_Hunger_Series_2006_Full(1).pdf. Accessed 13 Oct 2016.

Van Zyl, J., & Kirsten, J. (2010). Food security in South Africa. *Agrekon, 31*(4), 170–184.

Emmanuel Donkor is a holder of MPhil/MSc. Agricultural Economics from Kwame Nkrumah University of Science and Technology (Ghana) and University of the Free State (South Africa). His research interests include the adoption of agricultural technology, efficiency and productivity, land tenure, household food security, food value chains, impact assessment, climate change, agricultural extension, rural development and sustainability.

Dr. Yonas T. Bahta is a Senior Researcher, in the University of the Free State, Department of Agricultural Economics, South Africa. His research interests include trade, agricultural trade, modelling (SAM- CGE, Econometerics), socio-economic analyis, saving mobilization, food security, monitoring and evaluation, marketing, price analysis, macro-economic, policy analysis, Finance and development related issues.

Boipelo Elizabeth Tlalang is a part time post graduate student at the University of the Free State, Department of Agricultural Economics. Currently she is working as a Senior Agricultural Advisor at Gauteng Department of Agriculture, Conservation and Environment, South Africa. Her research interests include agricultural technology, land tenure, household food security, food value chains, agricultural extension and rural development.

Dr. Owusu-Sekyere, Enoch is an agricultural and development economist with Ph.D. in Agricultural Economics and MPhil in Development Economics. His research interest includes environmental impact assessments, sustainable water use, agricultural policy, food safety and quality policy, food security, technology adoption, rural development and environmental sustainability.