Agrekon

Agricultural Economics Research, Policy and Practice in Southern Africa

ISSN: 0303-1853 (Print) 2078-0400 (Online) Journal homepage: www.tandfonline.com/journals/ragr20

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To cite this article: Y.T. Bahta, E. Owusu-Sekyere & B.E. Tlalang (2018) Assessing participation in homestead food garden programmes, land ownership and their impact on productivity and net returns of smallholder maize producers in South Africa, Agrekon, 57:1, 49-63, DOI: 10.1080/03031853.2018.1437051

To link to this article: https://doi.org/10.1080/03031853.2018.1437051

Published online: 05 Mar 2018.

AGREKON, 2018
VOL. 57, NO. 1, 49–63
https://doi.org/10.1080/03031853.2018.1437051

Assessing participation in homestead food garden programmes, land ownership and their impact on productivity and net returns of smallholder maize producers in South Africa

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ABSTRACT
This paper examines the determinants of participation in homestead food garden programmes and its impact on productivity and net returns of smallholder maize producers in the Gauteng province of South Africa. The paper further establishes the nexus between land ownership and outputs from homestead food garden programmes. The data was obtained from 500 maize-producing households. The findings demonstrate that participation in homestead food garden programmes could significantly enhance the welfare of rural households by increasing their yield and net returns. Participation in the programme increased maize yield and net returns by 43.37 per cent and 22.01 per cent respectively. Cultivating more than one hectare of farmland enhanced the outcome of participation in a homestead food garden programme more relative to cultivating less than one hectare. Homestead food garden programmes should be run in conjunction with land ownership. Our findings demonstrate the need for policymakers and evaluators of agricultural interventions to consider farmers' decisions to participate, programme outcomes and land ownership in their assessments in order to avoid biased judgement. The willingness of people to participate in farming should be paramount to the homestead food garden programme and land ownership policy, otherwise the redistribution of farmland to people who are not willing to farm will be meaningless.

KEYWORDS
homestead food garden programme; land ownership; net returns; productivity; South Africa

JEL CLASSIFICATION
I380; Q110; Q120; Q150; Q180

1. Introduction

The rapid increase in global population, urbanisation and climate change has had major consequences for global agricultural production and land-use systems, coupled with their impact on environmental, social and economic development and sustainability. The increase in population and urbanisation threatens resource allocation, sustainable intensification of agriculture, food security and environmental sustainability (FAO, 2009). With the world's population projected to reach over nine billion by 2050, governments, stakeholders, development partners, practitioners and organisations are interested in the development and implementation of agricultural and farming systems that will have a positive impact on output from land use. In their quest for production systems and methods that intensify sustainable agriculture and food security, and increase the income and general wellbeing of people, the South African government and stakeholders in the agricultural sector have implemented certain transformational and developmental programmes. Some of the programmes are the Agriculture and Land Reform Policy (ALRP), the Comprehensive Agricultural

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Support Programme (CASP) and the South Africa Integrated Food Security Strategy (SAIFSS) (DAFF, 2014). One of the key agricultural programmes under the SAIFSS is homestead food gardening. The homestead food garden system combines different physical, social, institutional and economic functions on an area of land owned by households and families to produce food commodities (Galhena *et al*., 2013).

Homestead food gardening is well adapted to local agronomic and resource conditions and cultural and food preferences (International Institute of Rural Reconstruction [IIRR], 1991; Midmore *et al*., 1991). It is also considered as a more sustainable agricultural practice for improving food security and improving nutrition in rural areas, as well as for enhancing economic growth (Galhena *et al*., 2013). This system of production can be accessed by the poorest of people because it depends on low-cost, low-risk technology and can be adapted to a rapidly changing climate, drought, floods and other hostile environments (e.g., dryland gardens, flooding gardens). In terms of household food security, homestead food gardening provides direct access to food that can be harvested, prepared and fed to family members, often on a daily basis. Additionally, very poor, landless or near landless people can establish a garden on small areas of homestead land, vacant lots, roadsides or edges of a field, or in containers. These gardens can potentially be developed with virtually no economic resources, using locally available planting materials, green manures, "live" fencing and indigenous methods of pest control. This implies that, at some level, homestead food gardening can easily be adopted by the poor. Homestead gardens are usually only a few square metres in size or on small land areas around the family home. Households typically cultivate small land sizes for vegetables and other food crops consumed in the house. However, in the context of this study, smallholder maize producers participating in homestead food garden programmes extend their maize production beyond the homestead, especially those staying on farms or in locations with available farmland. The homestead garden programme seeks to encourage households to sustain and expand their production to increase production for home consumption and for the sale of surplus to generate income (GDARD, 2016).

It is worth noting, however, that the sustainability of a homestead food garden cannot be achieved without proper management (Midmore *et al*., 1991). There is a lack of understanding of what determines a household's decision to participate, and its failure to devote essential resources and to place the existing homestead food garden system in the context of varying household objectives (UNICEF, 1982; Midmore *et al*., 1991). Over the years, home gardens or improved garden programmes have been abandoned because the costs incurred by households exceed the benefits. Therefore, it is very important for programme implementers to critically evaluate the potential benefits and costs to ensure the sustainability of the programme. Many resource constraints can be examined and circumvented in order to sustain the programme.

In South Africa, existing studies have revealed that the system significantly improves vitamin A intake among children and supplements household food consumption (Faber *et al*., 2002; Nkosi *et al*., 2014; Pandey *et al*., 2016), as well as boosts nutritional security (Faber *et al*., 2011). However, the decision to participate, land ownership, productivities and net returns arising from participating in the homestead food garden system have not been explored, particularly in South Africa. The success of homestead food garden production is directly linked to land ownership because, without farmlands, homestead food gardening cannot be adopted by the targeted participants. Insight into the interactions between homestead food garden and land ownership systems is important for policy decision making and is needed to develop effective, efficient and sustainable agricultural interventions in developing economies such as South Africa. To the best of our knowledge, no study has examined the decision to participate in and the impact of homestead food garden systems with particular attention paid to land ownership in southern Africa. An understanding of the determinants and impacts of the project can assist in sustaining the programme. For instance, a detailed impact analysis that highlights the full benefits of the programme can potentially motivate households' participation.

The main objective of this study therefore was to examine the determinants of farmers' decisions to participate in homestead food garden programmes and the impacts of their decisions on productivity and net returns of maize farmers in South Africa. The impact of different land sizes on the productivity and net returns of maize farmers also was examined. Overall, the study provides the necessary policy information required for the formulation and modification of existing agricultural systems and land use policies aimed at reducing poverty, food insecurity, hunger and malnutrition as targeted by the post-2015 development agenda for the sustainable development goals. The remainder of the article is structured as follows. Section 2 gives a description of the homestead food garden programme. Section 3 presents the theoretical and empirical framework. Section 4 presents the data and sampling method. Section 5 presents the results and discussion, while Section 6 outlines the conclusions and policy implications.

2. Description of homestead food garden programme

The homestead food garden programme was introduced in 1997 as one of the government's responses to food insecurity, poverty, hunger and malnutrition in South Africa. The programme was aligned with the improvement of the income of households through the sale of surplus production from homestead food gardens (DARD, 2015). The Gauteng Department of Agriculture and Rural Development (GDARD) has a mandate to ensure that there are agricultural growth and development in the province, with a focus on empowerment, alleviation of hunger at the household level, poverty alleviation, income generation and job creation through the agricultural sector (GDARD, 2016). The homestead food garden programme targets the most vulnerable groups, such as women, the youth, the unemployed and poor households, in urban and peri-urban areas. The GDARD implements the Homestead Food Garden (HFG) programme on an annual basis (GDARD, 2016; Integrated Development Plan, 2016). The call for service providers for the 2016/2017 production year was opened on 30 September 2016, and the GDARD targeted 7 000 households in the 2016/2017 financial year (GDARD, 2016). In the 2015/2016 financial year, the department established 32 community gardens, 24 school food gardens and 5 945 household/homestead food gardens in the prioritised townships in the province (DARD, 2015).

The implementation starts with a call for service providers to supply garden tools, vegetable seeds, inorganic fertiliser, watering cans and compost (GDARD, 2016). Once the service providers are appointed, the department meets with the local municipalities to explain the target for that particular financial year. After meeting the local municipalities, the department calls a meeting with the ward councillors during which the programme is rolled out and the process is explained to them. Once the councillors agree, a public meeting is called to explain the programme to the members of the communities. Community members who voluntarily agree to take part in the programme are taken through a voluntary programme for six hours. The aim of this voluntary programme is to see the determination and willingness of the people to establish food gardens (DARD, 2015). After the voluntary programme, the department presents three days of training: nutrition (1st day), soil preparation and planting (2nd day) and maintenance, including pest control and water management (3rd day) (DACE, 2002; Rudolph *et al*., 2012). After successful completion of the training, the participants receive garden tools, vegetable seeds, inorganic fertiliser, watering cans and compost (GADS, 2006). The package includes farm tools like a spade, fork and rake, 10-litre watering cans, and a hoe, along with inputs like fertiliser, bags of compost and different types of seeds (cabbage, lettuce, carrots, maize, etc.) (GADS, 2006). The department does regular monitoring of established food gardens (Siyakhana Report, 2012).

3. Theoretical and empirical framework

For the purpose of this study, we consider that the maize farmer household maximises its utility subject to the technology of the maize production system, time constraints on household members and constraints on household cash income. The household's utility function can be specified as $U(Y, X_2, L)$, where Y is the quantity of maize consumed, X_2 is other goods consumed, and L is leisure time for household members. The household has a production function for maize of, where H_1 is family labour, $X_1$is purchased inputs for maize production, and ϕ_1 is technology for maize production (homestead food garden package). The time constraint is $T = L + H_1 + H_2$, where H_2 is household off-farm (wage) work. The cash income constraint is $V + W_2H_2 + P_Y(Y_1 - Y) - P_1X_1 - P_2X_2 = 0$, where V is non-farm (non-wage) income (i.e. non-farm asset income), W_2 is the wage for off-farm work, P_Y is the market price for maize, P_1 is the market price forX_1, and P_2 is the market price forX_2.

We can combine the cash income, time and technology constraints to get one full income constraint. A household can either be a net supplier of maize to the market, or demand maize from the market, depending on the sign of $Y_1 - Y$. We assume that there is no direct cost of adopting or participating in the homestead food garden programme or package, because adding some fixed cost would reduce the probability of households' participation in the homestead maize garden programme. The households' participation decision problem is set up so that the production decisions for Y_1 are separable from the consumption and labour supply decisions.

Production decisions on maize are made by maximising profit in choosing H_1, X_1 and ϕ_1. Under maximum profit, we specify that $H_1^* = d_{H_1}(P_Y, W, P_1, \phi_1^*)$ and $X_1^* = d_{X_1}(P_Y, W, P_1, \phi_1^*)$, where ϕ_1 is the choice of the maize production system that maximises profit. Now the farm's supply function for maize is obtained by substituting these demand functions and ϕ_1 into the production function to obtain $Y_1^* = S_Y(P_Y, W, P_1, \phi_1^*)$. Also, we denote the optimal profit from maize production as $\pi^*(P_Y, W, P_1, \phi_1^*)$. Following these, the utility maximisation problem conditioned on the profit-maximising solution for the production of maize is optimally specified as $Y^* = d_Y(V, P_Y, P_1, W, \pi^*)$. The optimal excess supply function for maize is then re-specified as $Y_1^* - Y^* = S_Y(P_Y, W, P_1, \phi_1^*) - d_Y(V, P_Y, P_1, W, \pi^*)$. The monetary value of maize is determined by multiplying this quantity by the price of maize in the market (Deaton, 1989).

Based on the economic foundation developed above, our empirical model is obtained by defining the indirect utility function for participants in the homestead food garden programme versus non-participants. To focus on the participants in a homestead food garden programme, we define the indirect utility function for participants in the programme as $U_{1i}(Z_{1i})$ and that of non-participants as $U_{0i}(Z_{0i})$. A random disturbance term is added to each indirect utility function to form an empirical model for participation in the homestead food garden programme. The probability of participating in homestead food garden programme is defined as:

$$\Pr[D_i = 1] = \Pr[U_{0i} + \mu_{0i} < U_{1i} + \mu_{1i}] = \Pr[\mu_{0i} - \mu_{1i} < U_{1i} - U_{0i}] \quad (1)$$

In this study, the utility or net benefit refers to the yield and net returns from maize production, given the transaction cost. Farmers choose between participating in the homestead food garden programme or not participating. Prior to the research, the benefits of the farmers' choices were not known to the analyst; what was known was the personal, farm, socioeconomic and institutional characteristics of the farmer, as well as the characteristics of the production system. Therefore, the choices of the farmers can be translated into a binary choice, which is examined using a binary choice model. The net benefit of the farmers' choices can be denoted by the latent variable U_{ij}^* and represented by two choice scenarios, as:

$$\begin{aligned} U_{ij}^* &= Z\lambda_{ij} + \mu_{ij} \\ U_{ij} &= 1, \text{ if } U_{ij}^* > 0 \\ U_{ij} &= 0, \text{ if } U_{ij}^* \le 0 \end{aligned} \quad (2)$$

where U_{ij} is a binary dependent variable that equals 1 if the farmer participates in a homestead food garden programme and 0 otherwise. Z_i is a vector of the individual, household, farm-level and homestead food garden programme characteristics and perception, λ_{ij} is a vector of parameters to be estimated and μ_{ij} denotes the random disturbance terms for participants and non-participants.

3.1 Endogenous switching regression (ESR) approach

To evaluate the impact of the homestead food garden programme on yield and net returns, the endogenous switching regression (ESR) model was employed, because participation in a homestead food garden programme is not randomly assigned. When building up the ESR model, we denote the net returns from maize production by Y_i^* and assert that this net return is a linear function of independent variables (X_{ij}) and a choice of maize production system (U_{ij}). The net return function is specified as:

$$Y_{ij}^* = \gamma X_{ij} + \alpha U_{ij} + \ell_i \tag{3}$$

where Y_{ij} is as defined above, γ and α are vectors of parameters to be estimated, ℓ is the error term with zero mean and constant variance, X is a vector of individual, household, farm-level and homestead food garden programme characteristics, as well as the perceptions of people in the programme. However, explanatory variables such as extension access and non-farm work are likely to be endogenous to the participation equation (Koundouri *et al*., 2006; Abdulai & Huffman, 2014). Hence, we addressed the potential endogeneity problem by expressing the variables as functions of all other exogenous variables in the participation equation (3), plus a set of instruments, and specified it as:

$$\Upsilon_{ij} = \gamma X_i + \phi I_{ij} + \xi_i; \quad j = 1, 2 \tag{4}$$

where Υ_{i1} denotes a binary variable for extension access and Υ_{i2} is a binary variable for participation in off-farm work, X is defined above, and I_i represents the set of instruments that are correlated with the endogenous variables but uncorrelated with the error term (ℓ) in Equation (3). The homestead food garden programme participation equation is re-specified as:

$$U_{ij}^* = \gamma X_{ij} + \omega_1 \Upsilon_{i1} + \omega_2 \Upsilon_{i2} + \varphi_1 R_{i1} + \varphi_2 R_{i2} + \nu_i \tag{5}$$

where X_i is as defined above, Υ_{i1} is the observed extension access, and Υ_{i2} is the observed off-farm work. R_{i1} andR_{i2} represent the residual terms obtained from the first-stage equation explaining determinants of extension access and off-farm work participation respectively. The addition of these residual terms is based on the control function approach highlighted by Wooldridge (2015) to account for endogeneity. In order to account for the selection effect, farmers' choice decisions should be considered in the analysis (Pitt, 1983). If the selectivity effect is not accounted for, the distribution of observed benefits arising from the homestead food garden programme will be truncated. This will cause the error terms of the participation (ν) and outcome equation (ℓ) to be correlated ($corr(\nu, \ell) = \rho$), which usually results from unobserved factors. If the unobserved factors are not considered, the use of the ordinary least estimation procedure will yield biased estimates (Abdulai & Huffman, 2014). Therefore, in order to use the probit estimates as determinants, the ESR approach is adopted, which also accounts for selection bias in this paper (Lee, 1982).

Since yield and net returns are observed for both the participants and non-participants in our study, the switching regression model categorises households as participants and non-participants in order to capture the differential response of the two sub-samples. If the household chooses to participate in the programme, the observed net benefits take the form of:

$$\pi_{i1} = Z_i'\lambda_{i1} + \mu_{i1} \text{ if } \mathrm{U}_{ij} = 1, \text{otherwise } \pi_{i0} = Z_i'\lambda_{i0} + \mu_{i0} \text{ if } \mathrm{U}_{ij} = 0, \tag{6}$$

where π_{i1} and π_{i0} are the outcome variables for homestead food garden programme participants and non-participants respectively, and Z_i denotes a vector of the individual, household, farm-level and homestead food garden programme characteristics and perception.λin Equation (6) is a vector of associated parameters to be estimated. However, it must be emphasised that the variables in vectors Z and X may overlap, and hence proper identification requires that at least one variable in X does not appear in Z. Farmers' perceptions of the benefits of the homestead food garden programme are used as the exclusion variable in our estimations. Ma and Abdulai (2016) indicate that the perception of farmers does not directly influence farm yield and net returns, but can significantly influence farmers' participation decisions. Therefore, this variable was excluded from the outcome equations. In such instances, self-selection into the participant or non-participant categories may result in a non-zero covariance between the error terms of the participation decision equation and the outcome equation. Consequently, the error terms ν, μ_{i1} and μ_{i0} are assumed to have a trivariate normal distribution, with a mean vector of zero and the following covariance matrix:

$$\text{cov}(\mu_{i1}, \mu_{i0}, \nu) = \sum = \begin{bmatrix} \xi_{i1}^2 & \xi_{i0} & \xi_{P\nu} \\ \xi_{i0} & \xi_{i0}^2 & \xi_{N\nu} \\ \xi_{P\nu} & \xi_{N\nu} & \xi_{\nu}^2 \end{bmatrix} \tag{7}$$

where $\text{var}(\mu_{i1}) = \xi_{i1}^2$, $\text{var}(\mu_{i0}) = \xi_{i0}^2$, $\text{var}(\nu) = \xi_{\nu}^2$, $cov(\mu_{i1}, \mu_{i0}) = \xi_{io}$, $cov(\mu_{i1}, \nu) = \xi_{P\nu}$ and $cov(\xi_{i0}, \nu) = \xi_{N\nu}$. The μ_{i0} and μ_{i1} in equation (6) have non-zero expected values, which are conditional on the sample selection criterion. Hence, ordinary least squares (OLS) estimates of λ_{i1} and λ_{i0} are affected by sample selection bias (Lee, 1982). Johnson and Kotz (1970) argue that the errors terms should be truncated and they are given as:

$$E(\mu_{i0}/\text{U}_{ij} = 0) = E(\mu_{i0}/\nu \leq -x'\gamma) = \xi_{N\nu}\frac{-\phi(x'\gamma/\theta)}{1 - \vartheta(x'\gamma/\theta)} = \xi_{N\nu}\lambda_{i0} \tag{8}$$

$$E(\mu_{i1}/\text{U}_{ij} = 1) = E(\mu_{i1}/\nu > -x'\gamma) = \xi_{P\nu}\frac{-\phi(x'\gamma/\theta)}{\vartheta(x'\gamma/\theta)} = \xi_{P\nu}\lambda_{i1} \tag{9}$$

where ϕ and ϑ denote the probability density and cumulative distribution functions respectively. λ_{i1} andλ_{i0} are inverse Mills ratios of ϕ and ϑ evaluated at $x'\gamma$. Inverse Mills ratios are integrated into Equation (6) to cater for bias in selection. To avoid a heteroskedasticity problem in such estimations, the participation and outcome equations are estimated simultaneously (Lokshin & Sajaia, 2004). A probit model was first estimated to determine the selectivity terms (λ_{i1}, λ_{i0}). The signs and significance of the correlation coefficients (ρ) from the simultaneous estimations are very relevant to determine the presence of endogenous switching and negative or positive selectivity effects. We first assessed the expected values of households' net returns. For a homestead food garden programme participant with characteristics Z and X, the expected net returns (π_{ij}) are specified as:

$$E(\pi_{i1}/\text{U}_{ij} = 1) = Z_{i1}\lambda_{i1} + \xi_{i1_{\nu}}\lambda_{i1} \tag{10}$$

The last term ($\xi_{i1_{\nu}}\lambda_{i1}$) accounts for sample selection. It explains whether households that participate in the homestead food garden programme may act differently from an average household with similar characteristics. Assuming that the same household did not participate in the homestead food garden programme, then Equation (10) is re-specified as:

$$E(\pi_{i0}/\text{U}_{ij} = 0) = Z_{i0}\lambda_{i0} + \xi_{i0_{\nu}}\lambda_{i0} \tag{11}$$

The difference between participation in Equation (10) and non-participation in Equation (11) is denoted as the change in net returns due to homestead food garden programme participation. This estimate is referred to as average treatment effect on the treated (ATT) (Smith & Todd, 2005). The ATT estimates from the ESR give an unbiased estimate of participation effects. To examine the counterfactual imaginary scenarios that the non-participants did participate and the participants did not participate is specified as:

$$E(\pi_{i0}/\text{U}_{ij} = 0) = Z_{i0}\lambda_{i0} + \xi_{i0_{\nu}}\lambda_{i0} - E(\pi_{i1}/U_{ij} = 1) = Z_{i1}\lambda_{i1} + \xi_{i1_{\nu}}\lambda_{i1} \tag{12}$$

3.2 Propensity score-matching (PSM) approach

The propensity score-matching (PSM) approach was employed to estimate the impact of land ownership through the land redistribution policy on yield and net returns of maize farmers. This approach compares the outcomes of maize farmers owning more than one hectare of farmland with those who own less than one hectare of farmland. We assume that there is no selection bias arising from unobservable factors, because the quality of individuals' proposals determines whether the application for land will be successful or not (Aliber *et al.*, 2013). The propensity score-matching technique compares the outcomes of maize farmers owning more than one hectare of farmland (treated) and those who own less than one hectare of farmland (controlled). We first generated the propensity score of owning more than one hectare of farmland using a probit model. Secondly, the ATT based on the predicted propensity scores was estimated. The propensity score matching is specified as:

$$\Pr(Z_{i1}) = \Pr(\mathrm{U}_{ij} = 1/X_{i1}) = E(U_{ij}/X_{i1}) \tag{13}$$

where $\mathrm{U_{ij}} = \{0, 1\}$ gives an indication of whether the farmer owns more than one hectare of farmland or not, and X_1 denotes farm characteristics. The ATT π_{ATT}^{PSM} can be specified as:

$$\pi_{ATT}^{PSM} = E[\pi_{i1}/\mathrm{U}_{ij} = 1] - E[\pi_{i0}/\mathrm{U}_{ij} = 1] = X(\lambda_{i1} - \lambda_{i0}) + (\xi_{i1_v} - \xi_{i0_v})\lambda_{i1} \tag{14}$$

The most widely used matching algorithms, such as the nearest neighbour (NNM), kernel-based (KBM) and radius matching algorithms, are employed to estimate the ATT (Ma & Abdulai, 2016).

4. Data and sampling

The 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 homestead food garden programme. The second stage involved the random selection of three metropolitan municipalities and two district municipalities in the province using balloting. The three metropolitan municipalities selected were the city of Johannesburg, the city of Tshwane and the city of Ekurhuleni, and the two district municipalities were West Rand and Sedibeng. Seventy-seven households were randomly chosen from Johannesburg, 78 from Tshwane, 103 from the West Rand, 131 from Ekurhuleni, and 111 from Sedibeng. It must be emphasised that the reasons for selecting specific numbers of households from different locations were based on the proportion of maize-producing households in each location (Kothari, 2004).

Simple random sampling was used to select participants and non-participants in the homestead food garden programme from the selected locations. A list of participating and non-participating maize farmers was prepared with the help of officers of the DAFF in the selected areas. From the list generated, 20 participants and 57 non-participants were sampled from Johannesburg, 28 participants and 50 non-participants from Tshwane, 59 participants and 44 non-participants from the West Rand, 66 participants and 65 non-participants from Ekurhuleni, and 61 participants and 50 non-participants from Sedibeng. In total, 500 rural farmers were selected, comprising 234 participants in the homestead food garden programme and 266 non-participants. The survey data were collected from the households in 2015 using a structured questionnaire. The questionnaire solicited information regarding yield, revenue, costs, the homestead food garden programme, asset endowments, and institutional, farm and socioeconomic characteristics related to the households. Part of the data solicited was used in examining the impact of the homestead food garden programme on food security in South Africa (Bahta et al., 2018).

5. Results and discussion

5.1 Descriptive and summary characteristics of homestead food garden participants and non-participants

Socioeconomic and institutional characteristics of participants and non-participants in the homestead food garden programmes are presented in Table 1. Mean differences in characteristics

Table 1. Socioeconomic and institutional characteristics of participants and non-participants

Variable	Description	Participants N = 234 (46.80%)	Non-participants N = 266 (53.20%)	Mean difference
Outcome variable				
Yield	Maize output (kg/ha)	2409.19 (900.96)	1841.17 (776.36)	568.02***
Net returns	Revenue minus variable input costs per hectare in ZAR	9721.07 (3635.37)	7429.10 (3132.63)	2291.97***
Independent variables				
Household characteristics				
Age	Age of farmer in years	40.03 (7.06)	44.54 (14.87)	−4.51***
Education	Years of formal education	12.04 (1.95)	9.82 (2.46)	2.22***
Household size	Number of household members that assist in farm	2.88 (2.25)	4.71 (2.34)	−1.82***
Gender	1 if male, 0 otherwise	0.66 (0.48)	0.52 (0.50)	0.14***
Off-farm activity	1 if farmer engages in off-farm activity	0.53 (0.50)	0.47 (0.50)	0.06
Remittances	1 farmer received any financial remittance, 0 otherwise	0.57 (0.52)	0.61 (0.50)	0.04
Farm characteristics				
Farm size	Area of land under maize cultivation (ha)	2.15 (1.36)	1.57 (0.75)	0.59***
Livestock	1 if household owns livestock, 0 otherwise	0.781 (0.42)	0.39 (0.49)	0.39***
Distance	Distance from farm to market (km)	13.53 (12.33)	10.47 (13.73)	3.06*
Market access	1 if farmer has access to market, 0 otherwise	0.60 (0.49)	0.60 (0.49)	0.00
Family labour	1 if farmer uses family labour, 0 otherwise	0.58 (0.50)	0.64 (0.48)	−0.06
Irrigation	1 if farmer used irrigation for production, 0 otherwise	0.71 (0.46)	0.65 (0.48)	0.06
Fertilizer usage	1 if farmer used chemical fertiliser, 0 otherwise	0.79 (0.41)	0.52 (0.51)	0.27***
Improved usage	1 if farmer used improved seed, 0 otherwise	0.81 (0.38)	0.77 (0.42)	0.04
Institutional characteristics				
Extension	1 if farmer has access to extension services, 0 otherwise	0.77 (0.42)	0.33 (0.47)	0.43***
Credit access	1 if farmer has access to formal credit, 0 otherwise	0.62 (0.49)	0.35 (0.48)	0.28***
FBO	1 if farmer belongs to any farmer based organisation	0.67 (0.47)	0.86 (0.35)	−0.17***
Perception	Homestead garden perception index	2.25 (0.93)	1.95 (1.08)	0.30***

Source: Authors' calculation.
*, **, *** denote 10%, 5% and 1% significant levels respectively.

between participants and non-participants were tested using the T-test, and the results are presented in the last column of Table 1. Of the 500 farmers, 46.8 per cent (234) were participants in the homestead garden programme and 53.2 per cent (266) were non-participants. The results show that, on average, homestead garden programme participants obtained 2 409.19 kg of maize per hectare, while non-participants obtained 1 841.17 kg per hectare in the 2015 production season. Homestead food garden programme participants on average obtained about 568.02 kg of maize more than the non-participants. In terms of net returns, we found that there was a highly significant mean difference of ZAR 2 291.97 between homestead garden participants and non-participants. This suggests that the net return of homestead garden participants is 30.85 per cent higher than that of non-participants. The differences in yield and net return cannot be attributed to the homestead food garden programme because of the confounding effect of unobserved factors (Abdulai & Huffman, 2014).

Participants in the homestead food garden programme were about four years younger than non-participants, as shown by the significant mean difference at the 1 per cent level. This concurs with the objective of the homestead garden programme, which seeks to create jobs for the youth. Homestead food garden programme participants had about two years more education than non-participants. Non-participants had larger households relative to participants, as shown by the significant mean difference of −1.82. The homestead food garden programme is dominated by males (66%) relative to females (34%). Similarly, males dominate among the non-participating maize farmers (52%). This means that there are gender disparities in maize production in the study area. About 53 per cent of homestead food garden participants engage in off-farm activities, compared with 47 per cent of non-participants. About 57 per cent of participants and 61 per cent of non-participants received financial remittances during the production season.

Regarding farm characteristics, the results show that participants in the homestead garden programme cultivated 0.59 hectares of maize more than non-participants. Non-participants in the homestead garden programme covered 3.06 km more to reach the market on average compared with participants. About 60 per cent of both homestead food garden participants and non-participants had easy access to the market. However, the above results indicate that access to the market is still a challenge in the study area, as about 40 per cent of both categories of farmers did not have access to the market. Most of the farmers in both categories relied on family labour. In both categories of farmers, access to irrigation was moderate, as 71 per cent and 65 per cent of participants and non-participants respectively had access. Similarly, the use of chemical fertiliser was low among non-participants in the study area, since only 52 per cent of them applied fertiliser, relative to 79 per cent of participants. This suggests that, although participants had access to chemical fertilisers, about 21 per cent of them did not use the fertiliser obtained. The majority of both participants and non-participants used improved maize seeds, as shown by the 81 per cent and 77 per cent for participants and non-participants respectively.

Concerning institutional characteristics, most of the participants in the homestead garden programme had access to extension services relative to non-participants. The significantly positive mean difference of 0.43 indicates that participation in homestead programmes facilitated access to extension services. Only 33 per cent of non-participants had access to extension services. On average, 62 per cent of the homestead garden participants had access to credit, compared to 35 per cent of the non-participants. About 67 per cent of participants were members of farmers' associations, whereas 86 per cent of non-participants were members of farmers' associations. The perception index for homestead food garden programme participants was higher than that of non-participants.

5.2 Empirical results of the determinants of farmers' participation decision and effects of the homestead food garden programme on maize output and net returns

Tables 2 and 3 present the results from the two-stage endogenous switching regression model. Table 2 presents the determinants of homestead food garden participation and effects on maize yield. The estimates of the selection equations in Tables 2 and 3 are determinants of maize farmers' participation in the homestead food garden programme. These estimates are discussed together, since they are all explanatory factors that influence participation in the homestead food gardening programme. The results demonstrate that, in both specifications, farmers' years of formal education is significantly positive, suggesting that the likelihood of maize farmers participating in the homestead food garden programme increases as their level of education increases. This concurs with the findings of Huffman (2001), who revealed that education has a significant impact on farmers' decisions to participate in sustainable agricultural interventions. The higher the number of household members who can help on the farm, the higher the likelihood that the farmer will participate in homestead food gardening. Male farmers are more likely to participate in the homestead food garden programme relative to females. Remittances impact positively on farmers' decisions to participate in the homestead food garden programme.

Farmers who own large farmlands are more likely to participate in homestead food garden programmes, as indicated by the significantly positive coefficient estimate for the owned land variable in both specifications. Farmers who rely on family labour are more likely to participate in a homestead food garden programme. Access to irrigation facilities, chemical fertiliser and herbicide application significantly facilitate maize farmers' participation in a homestead food garden programme. This is in line with the findings of Abdoulaye and Sanders (2005) and the aim of the homestead food garden programme, as it supports participants with traditional irrigation facilities like watering cans and hose pipes (Genius *et al*., 2014). This might also be linked to the fact that participation in

Table 2. Endogenous switching regression estimates for participation and maize yield

Variable	Selection	Maize yield	
		Participants	Non-participants
Constant	−0.134 (−0.48)	−1.037 (−0.32)	1.243* (1.82)
Age	−0.105 (−1.58)	0.295* (1.90)	0.155 (1.36)
Education	0.546** (2.44)	3.555*** (3.93)	4.167** (2.45)
Household size	1.101** (2.18)	3.242** (2.37)	1.237 (1.34)
Off-farm activity	−0.349* (1.85)	1.354** (2.38)	0.663 (1.54)
Gender	0.168*** (3.02)	0.323*** (3.10)	0.204 (0.11)
Remittances	0.477* (1.80)	2.112** (2.44)	0.543 (0.21)
Farm size	0.398** (2.86)	0.136* (1.86)	0.332** (2.14)
Family labour	0.122** (2.27)	1.771** (2.46)	3.202** (2.28)
Herbicide	0.434** (2.36)	1.962** (2.37)	2.218** (2.18)
Irrigation	0.316** (2.02)	2.112**(2.44)	0.543 (0.21)
Fertiliser usage	0.475** (2.16)	1.168* (1.67)	0.387** (2.47)
Improved seed	0.410** (2.05)	0.458** (2.46)	0.204** (2.57)
Extension	0.266** (2.26)	4.675** (2.22)	1.374* (1.84)
Credit access	0.035** (2.02)	3.347*** (4.42)	2.698** (2.33)
Livestock	0.473 (1.09)	3.009*** (3.54)	2.322* (2.51)
FBO	2.425*** (5.21)		
Perception	1.303*** (3.14)		
Residaloff_farm activity	0.333 (1.02)		
Residal_extension	1.009 (0.99)		
LR test of independence	22.13***		
Log likelihood	−115.47		
Chi-square ($\chi 2$)	0.794 (0.57)		
lns0			−0.851*** (7.05)
ρ_{NP}			−0.222 (−0.72)
*lns*1		−2.614*** (−19.31)	
ρ_{PA}		−0.727*** (3.80)	

Source: Authors' calculation.
*, **, *** indicates significance at 10%, 5% and 1% levels. Values in parentheses are *t*-values.

the homestead food garden programme supports farmers with such inputs. Farmers who have access to improved seeds are more likely to participate in homestead food gardening.

Regarding institutional factors, the results indicate that farmers who have access to extension services have a higher probability of participating in homestead food gardening. This emphasises the relevance of agricultural extension in providing vital information on efficient and sustainable agricultural programmes in developing countries. Farmers who have access to credit are more likely to participate in a homestead food garden programme. This emphasises the relevance of access to credit in facilitating farmers' participation in livelihood improvement interventions. Farmers who are members of farmer-based organisations are more likely to participate in homestead food gardening programmes. This corresponds to the idea that farmers' social capital enhances information sharing, which tends to facilitate participation in sustainable farming programmes (Bandiera & Rasul, 2006). Furthermore, farmers' decisions to participate in homestead food garden programmes are highly dependent on their perception of how viable the programme is. This is shown by the highly significant and positive estimate for the perception variable. This suggests that implementers of the homestead food garden programme can influence farmers to participate in the programme by creating a positive mental attitude among farmers. This supports previous findings by Levidow *et al*. (2014).

The third and fourth columns of Tables 2 and 3 present factors that influence maize yield and net returns for both participants and non-participants. The empirical results reveal that a farmer's age impacts positively on maize yield and net returns among participants in the homestead food garden programme. This implies that experienced maize farmers obtain a higher yield and net returns under the homestead food garden programme. Education has a positive impact on the maize yield and net returns of participants in the homestead food garden programme, concurring with the findings of Aubert *et al*. (2013). This provides further support for facilitating easy access to education, particularly in poor rural communities. Male participants in the homestead garden

Table 3. Endogenous switching regression estimates for participation and net returns

Variable	Selection	Net returns	
		Participants	Non-participants
Constant	−0.134 (−1.48)	−1.137 (−1.32)	1.143* (1.83)
Age	−0.303 (−1.48)	0.295*** (2.91)	1.040 (1.46)
Education	1.336*** (2.49)	3.055*** (2.93)	2.067** (2.46)
Household size	1.532*** (3.44)	3.347*** (2.99)	1.786 (0.87)
Off-farm activity	−0.159 (0.43)	0.543 (1.54)	0.354 (1.48)
Gender	1.101** (2.28)	0.242** (2.47)	0.237 (1.33)
Remittances	0.377* (1.83)	6.443*** (2.98)	2.432 (1.55)
Owned land	0.498* (1.92)	0.466* (1.66)	0.102** (2.14)
Family labour	3.102 ** (2.27)	2.061** (2.35)	1.502** (2.28)
Distance	0.148 (1.28)	−2.209** (−2.63)	−1.041** (−2.47)
Market access	0.239 (1.45)	0.214** (2.33)	0.183* (1.74)
Herbicide	0.434** (2.36)	1.962** (2.37)	2.218** (2.18)
Irrigation	0.375*** (3.00)	1.668*** (3.68)	0.387** (2.57)
Fertiliser usage	0.315*** (3.38)	2.467*** (3.59)	0.367** (1.98)
Improved seed	1.214* (1.81)	2.558** (2.46)	2.004** (2.47)
Extension	0.366** (2.36)	0.675** (2.42)	0.324* (1.85)
Credit access	2.035** (2.02)	3.347*** (4.19)	2.698*** (3.28)
Livestock	0.213 (1.05)	6.666** (2.57)	1.095** (2.45)
FBO	0.178** (2.36)	4.563** (2.18)	2.572** (2.26)
Perception	0.450*** (2.61)		
Residaloff_farm activity	1.156 (0.78)		
Residal_extension	1.887 (1.50)		
LR test of independence	23.13***		
Log likelihood	−122.57		
Chi-square ($\chi 2$)	0.565 (0.77)		
lns0			−1.441*** (−6.05)
ρ_{NP}			−0.433 (−0.53)
lns1		3.413*** (−10.21)	
ρ_{PA}		−2.233* (1.83)	

Source: Authors' calculation.
*, **, *** indicates significance at 10%, 5% and 1% levels. Values in parentheses are *t*-values.

programmes obtain greater yield and net returns relative to female farmers. Farm size impacts positively on the yield and net returns of maize farmers. This implies that ownership of farmland plays a significant role in enhancing maize yield and net returns.

Family labour impacts positively on the maize yield and net returns of participants in the homestead food garden programme. The longer the distance to the maize market, the lower the net returns of participants in homestead food garden programmes. Farmers' access to markets, credit and extension services has a positive impact on their yield and net returns. This is in line with the findings of Kassie *et al*. (2011) among Ugandan farmers. Remittances impact positively on the yield and net returns of homestead food garden participants. The use of chemical fertiliser, herbicides and irrigation increases maize yield and net returns of participants. This concurs with the findings of Levidow *et al*. (2014) and provides the rationale for farmers to be supported with farm inputs like fertiliser, herbicide and irrigation facilities. The use of improved maize seeds has a positive impact on yield and net returns of both participants and non-participants in homestead food garden programmes (Julius *et al*., 2016). Livestock ownership impacts positively on the maize yield and net returns of homestead food garden participants.

Finally, the residuals of off-farm activity and extension services are statistically insignificant in both specifications, indicating that the estimations are consistent. The results of the significant likelihood ratio test in both equations for joint independence show that the equations are dependent. The insignificant chi-square statistics in both specifications for over-identification implies that farmers' perceptions and membership of farmer-based organisations influence maize farmers' participation in homestead food garden programmes through access to extension and off-farm activity. Self-selection occurs in maize farmers' participation in homestead food garden programmes, as indicated by the significant covariance terms. This means that participation in homestead food garden programmes might have a different impact on the non-participants if they decided to participate in the programme.

The negative sign for ρ_{PA} reveals the existence of positive selection bias, which means that maize farmers whose yield and net returns are above average are more likely to participate in the homestead food garden programme. The insignificant ρ_{NP} statistic further shows that, without participation in a homestead food garden programme, both categories of farmers will behave similar yield and net returns on average.

5.3 Impact of the homestead food garden programme and land ownership on yield and net returns

The impact of a homestead garden programme on the yield and net returns of maize farmers from the ESR are presented in Table 4. The empirical results from the average treatment effect show that there are highly significant differences in maize yield and net returns of homestead food garden participants and non-participants. The causal effect of participating in a homestead food garden programme on maize yield is 1 499.60 kg of maize per hectare. This implies that participation in a homestead food garden programme significantly increases maize yield, by 43.37 per cent. In terms of net returns, it was found that the net return of participants in a homestead food garden programme is about 22.01 per cent higher than that of non-participants. The above results indicate that participation in a homestead food garden programme impacts positively on the yield and income of maize farmers. This is in line with the findings of Julius *et al*. (2016) in rural Zambia.

Table 5 presents the average treatment effect of different farm sizes on the yield and net returns of homestead food garden participants and non-participants using the PSM approach. The results indicate that only 35 per cent of the respondents cultivated more than one hectare of farmland, compared with 65 per cent who cultivated less than one hectare. The average treatment effects from the PSM estimations for farmers who cultivate more than one hectare of land indicate that participation in a homestead food garden programme resulted in a 44.63 per cent to 47.47 per cent increase in maize yield using the nearest neighbour, kernel-based and radius matching principles. Similarly, the causal effect of participating in a homestead food garden programme for farmers who cultivate more than one hectare of farmland is an increase in net return from 17.30 per cent to 22.59 per cent, using the same matching principles.

For farmers who cultivate less than one hectare of farmland, the findings reveal that the causal effect of participating in the homestead food garden programme is an increase in maize yield from 32.77 per cent to 53.97 per cent, using the three matching principles mentioned above. In terms of net returns, participation in a homestead food garden programme results in an increase from 19.65 per cent to 27.28 per cent for farmers who cultivate less than one hectare of farmland. The conclusion drawn from these findings is that the yield and net returns of farmers who cultivate more than one hectare of farmland are higher than those who own less than one hectare of farmland. The above results suggest that homestead maize production is very productive and economically efficient among households who cultivate large farmlands. These findings provide the rationale for homestead food garden programme implementers to consider land ownership in their programme implementation policies.

Table 4. Impact of homestead garden programme participation on maize yield and net returns: ESR estimates

	Participants	Non-participants	ATT	T-value	Change (%)
Yields (kg/ha)	3457.50	1957.90	1499.60***	16.70	43.37
Net returns (Rand/ha)	11250.44	8774.35	2476.09***	27.73	22.01

Source: Authors' calculation.
*** denotes 1% significant level.
ATT = average treatment effect.
ASWDERaaaaaasdfgzzx

Table 5. Average treatment effect of land ownership on yield and net returns of homestead food garden participants and non-participants: PSM

Matching algorithm	Mean outcome: Participants $N = 234$ (46.80%) (Treated)	Mean outcome: Non-Participants $N = 266$ (53.20%) (Controlled)	ATT	*t*-Value	% change
Land size > 1 hectares *N* = 175 (35%)					
Nearest neighbour matching (NNM)					
Yields (kg/ha)	3897.50	2047.45	1850.05	15.55***	47.47
Net returns (ZAR)	10574.44	8185.95	2388.49	21.01***	22.59
Kernel-based matching (KBM)					
Yields (kg/ha)	3805.80	2107.09	1698.71	14.50***	44.63
Net returns (ZAR)	10774.10	8910.45	1863.65	20.89***	17.30
Radius					
Yields (kg/ha)	3916.82	2117.19	1799.63	14.50***	45.95
Net returns (ZAR)	10999.51	8989.58	2009.93	20.71***	18.27
Land size < 1 hectares *N* = 325 (65%)					
Nearest neighbour matching (NNM)					
Yields (kg/ha)	2667.89	1227.99	1439.90	12.50***	53.97
Net returns (ZAR)	7989.70	5809.90	2179.80	19.01***	27.28
Kernel-based matching (KBM)					
Yields (kg/ha)	2687.69	1807.05	880.64	13.80***	32.77
Net returns (ZAR)	8097.88	6505.97	1591.91	17.06***	19.65
Radius					
Yields (kg/ha)	2957.89	1807.85	1150.04	20.99***	38.88
Net returns (ZAR)	8744.50	6445.90	2298.60	21.44***	26.29

Source: Authors' calculation.
*** denotes 1% significant level.

6. Conclusions and policy implications

The present paper evaluated the determinants of participation in a homestead food garden programme and its impact on the productivity and net returns of smallholder maize producers in the Gauteng province of South Africa using data from 500 maize-producing households. The paper assessed the impact of participating in the programme by relating it to land ownership, which is a very relevant policy issue in South Africa. Based on the study's findings, the following conclusions can be drawn. Personal and household characteristics, such as being a male, years of formal education, household size and remittances, positively influence farmers' participation in the homestead food garden programme. Farm characteristics such as the size of farmland, family labour and access to irrigation facilities, fertilisers, herbicides and improved seeds have a positive effect on farmers' participation decisions. Institutional factors such as access to extension services and credit, as well as the formation of farmer-based organisations, facilitate farmers' participation in the programme. Participation in homestead food gardens has a significant positive impact on the yield and net return of maize farmers.

Households owning more than one hectare of farmland have a significantly higher yield and net returns compared with those who own less than a hectare. Maize production is productive and economically efficient in terms of yield and net returns when produced on a large scale, particularly among participants in a homestead food garden programme. There is a positive selection bias in participation in a homestead food garden programme. The study suggests that, in order to promote and sustain the homestead food garden programme, policymakers should consider the facilitation of easy access to credit and markets, and the use of fertiliser, herbicides, improved seeds and irrigation facilities as important policy options. From an institutional point of view, programme implementers and policymakers should train and educate beneficiaries of the programme. This can be ensured by strengthening extension service delivery to reach more beneficiaries. The formation of farmer-based organisations is also an important policy option, which can be employed to improve participation and sustain the homestead food garden programme in South Africa.

Given the significant contribution of the programme to yield and net returns, policymakers in South Africa should encourage more households to participate in the homestead food garden programme. Other municipalities in South Africa seeking to improve food security and the standard of living of smallholder farmers can implement such a livelihood-improvement programme. The presence of selection bias suggests that future research on developmental programmes such as homestead food garden interventions should consider both farmers' participation decisions and the outcomes of the intervention in order to avoid bias in programme evaluation. Since farm size has a significant implication for the outcomes of the homestead food garden programme, the study suggests that policymakers should consider land ownership as a key factor if the aim is to sustain the homestead food garden programme. Additionally, the distribution of farmland should be accompanied by food policy programmes such as the homestead food garden programme.

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