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Effects of Cultivated Area on Smallholder Farm Profits and Food Security in Rural Communities of the Eastern Cape Province of South Africa

Nyarai M. Mujuru and Ajuruchukwu Obi *

Department of Agricultural Economics and Extension, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa; nmujuru82@yahoo.co.uk

* Correspondence: aobi@ufh.ac.za

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Abstract: As rural poverty deepens over much of Sub-Saharan Africa, smallholder transformation has become more urgent than ever before. A majority of rural people derive their livelihoods from agriculture, hence the urgent need for transforming the sector. The South African government launched a comprehensive land reform programme at the dawn of democracy in the country on the assumption that constraints on land size would be eliminated to make room for a more inclusive agricultural economy. The present study sought to assess how cultivated area affects food security and the profits of maize and cabbage farmers. The purposive sampling technique was used for the selection of study sites, from which 158 irrigators and homestead gardeners were selected. The data were then subjected to analysis by defining a maximum likelihood estimator that combines the seemingly unrelated regression (SUR) and one-way error correction model, to determine the factors influencing food security and farm profits. The model revealed diverse relationships, suggesting that location, farm type and income were important variables in explaining food security. The area under cultivation was found to influence profits for both crops. Policies in favour of technology adoption, market access and input use would greatly incentivize farmers to cultivate larger plots of land.

Keywords: profitability; food security; smallholder crop enterprise; seemingly unrelated regression analysis

1. Introduction

Smallholder farmers face various constraints in their efforts to engage in profitable agriculture [1]. Commercialization is a crucial development pathway for subsistence agriculture. However, in rural parts of Africa, smallholder farmers consume the bulk of their farm output [2], a situation that limits their participation in output markets. In addition to other constraints, overall productivity will be adversely affected. Several studies have established a positive correlation between agricultural productivity and food security [3–5]. The international development system considers that "food security" is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [6]. In this regard, the ability of households to access food through production, purchase or transfers becomes important in defining household food security [7]. Hence, household food security can be examined as a function of the availability of food within the country and the level of household resources necessary to produce or purchase food as well as other basic needs.

Smallholder farming communities in South Africa are still locked into low-productivity traditional technologies that have negative consequences on output and livelihoods [8]. Low farm productivity jeopardises food security and poverty alleviation efforts and restricts smallholder farmers' ability to exploit the opportunities that currently exist in the global food system [9] as well as national systems. Christiansen and Chuhan-Pole [10] found that 59.2% of African labour is employed in agriculture and 78.2% of this proportion is poor. Eastern Cape Province, with a population of 6,498,700 [11] was the poorest province in 2019, with nearly 60% of households dependent on social grants [12]. The province has a high official unemployment rate of 37.4%, an expanded unemployment rate of 48.3% and an adult poverty rate of 67.3% [12]. According to the 2016 Community Survey, the highest proportion of agricultural households per province was recorded for the Eastern Cape; at 27.9%, this was down from 35.4% in 2011 but high compared to the national average of 13.8%. With such a high dependence on agriculture, an inclusive environmental policy that promotes agricultural productivity would contribute to the reduction of unemployment and alleviate poverty in the province.

According to Fabiya et al. [13], agriculture is an essential sector in most developing countries. Even though the sector makes only a small contribution (2.2%) to South Africa's Gross Domestic Product (GDP), it is still vital for rural development, contributing 5.2% to employment growth [14]. The contribution of agriculture to GDP in South Africa continues to decline, but agriculture continues to play a major role in improving livelihoods [15]. In addition, 86% of the South African population depends on smallholder agriculture for livelihood and food security [16].

It has been forecasted that 60% more food is required if the global population increases to 9 billion by 2050 [17]. Edgerton [18] argued that the increasing demand for food can be met through either cropland expansion or increased productivity. However, given the environmental and economic constraints on cropland expansion due to population growth and urbanization limiting the available land, future increases in food production will have to come from sustainable intensification by enhancing productivity on existing agricultural lands through fertilizers and advanced irrigation and adopting new farming methods like precision farming [19]. This has implications for sustainable food security through increased efficiency and profitability. The argument that smallholder productivity and profitability is the only meaningful way to achieve growth for the sector by lifting millions out of poverty is an important one [20]. This means that national governments must formulate policies to support efforts to enhance the productive capacities of their food systems. Sartorius and Kirsten [21] argue that the commercialization of small farms into agribusiness units in South Africa would make smallholder contracting an attractive source of raw commodity supply, thereby modernizing their supply chains and improving productivity. This, of course, does not necessarily imply scale expansion and an increase in farm size, which may be influenced by several factors beyond the control of farmers.

Smallholder commercialization is part of an agricultural transformation process in which individual farms shift from a highly subsistence-oriented production towards more specialized production targeting markets both for their input procurement and output supply [22]. An agricultural production unit attains commercialization when product choice and input use decisions are based on profit maximization considerations [23]. Commercialization has a comparative advantage over subsistence production and hence has often been viewed as a way to improve household food security. However, there are arguments for and against smallholder commercialization as a pathway for ensuring household food security [24]. Smallholder commercialization amounts to more specialized production systems being capable of exploiting comparative advantages in resource use. Consequently, specialization leads to higher productivity through economies of scale, greater learning by doing, regular interaction, exposure to new ideas through trade, and better incentives in the form of higher income, which can achieve welfare gains for smallholder farmers [22,25]. Commercialization leads to the reallocation of resources towards nonagricultural activities and locations where labour is more productive. Nagler and Naudé [26] found out that 42% of the 25,551 rural households surveyed from a sample of Sub-Saharan countries operated a nonfarming household enterprise. Such nonagricultural income contributed 9% and 36% towards household income in Malawi and Niger, respectively. In this context, commercialization affects various aspects of the household conditions, including production and productivity, incomes, and food and nutrition security.

Smallholder agriculture in the Eastern Cape Province is highly subsistence-based, coupled with low productivity and resulting in very low incomes. Several government initiatives targeting the improvement of rural livelihoods in the province have failed to yield the expected results. With the land reform programme, revitalization of irrigation schemes and other farmer support schemes, one would expect the irrigation schemes to be fully operational and producing at full capacity. Lack of managerial competency and the inexperience of smallholder farmers probably explain the slow uptake of technology at the firm level [27]. However, land remains underutilized as farmers continue to cultivate small plots [28]. The extent of underutilization of available land in the smallholder sector is revealed by the fact that, of the estimated 35 million hectares of agricultural land in the black areas of the country [29], only about 14 million are being cultivated [30], representing about 40% utilization, which manifests in small farm sizes. One frequent explanation for this is that traditional tenure practices make the local chieftains the sole custodians of community land, which allows them to allocate much of it to their cronies while the rest are squeezed into what little remains [31,32]. Other explanations for the persistent small farm sizes are the inability to engage markets and the possible fallout of climate change and other constraints that depress productivity and act as disincentives to scale expansion [33]. In the event that surpluses arise in the farming system, it is not always clear where they go. Huge institutional gaps across markets—not limited to land, finance, insurance and input and output markets—remain in supporting smallholder competitiveness [34,35].

The agricultural sector is a key focus of the New Growth Plan, which was launched about 10 years ago by the government to create 5 million jobs by 2020. At the same time, the Medium-Term Strategic Framework of the Department of Agriculture, Forestry and Fisheries (DAFF) emphasizes agriculture as a focus area for job creation [36]. The focus on cropland expansion through land acquisitions shows that the government of South Africa acknowledges that increasing the area under cultivation is crucial for achieving meaningful and sustainable smallholder transformation. In his 2017 SONA Speech, the President of South Africa pointed out that there was a 19% decrease in agricultural households from 2.9 million in 2011 to 2.3 million in 2016. The decline was attributed to a severe drought that resulted in a decline in field crop production volume of 12.7% over the same period. This resulted in a reduction in the area under cultivation. Therefore, given the decline in agricultural households and crop production, the increase in smallholder production can be met through full utilisation of the available land [37]. It is against this backdrop that the study seeks to ascertain if the area under cultivation influences food security and crop profits and determine the prospective relationship between the two.

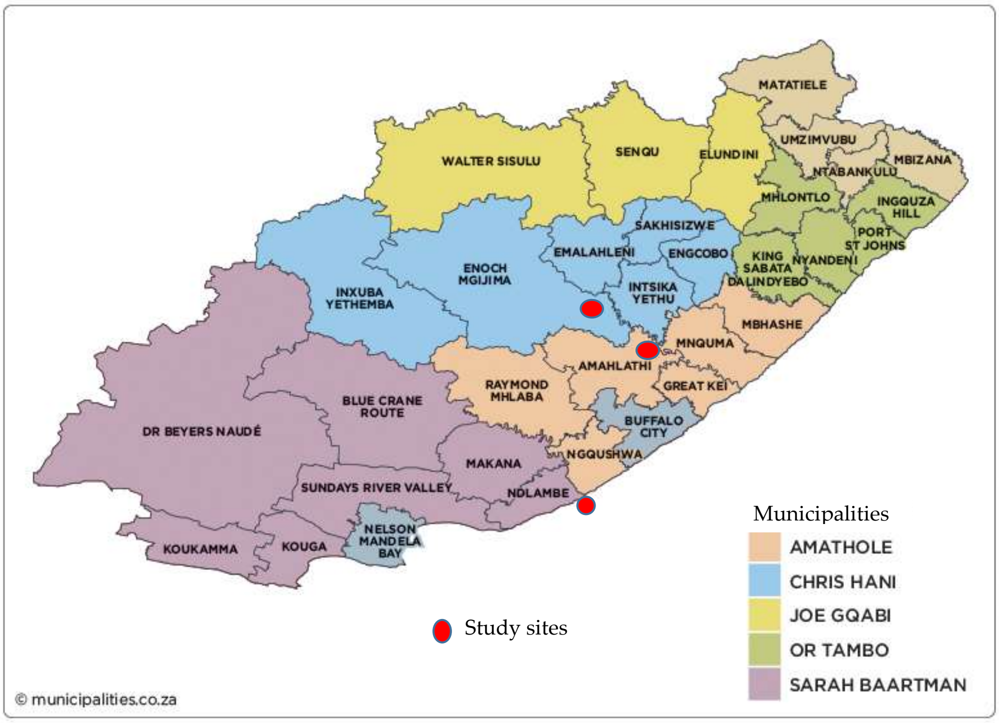
The paper is structured into five sections. Section 1 outlines the background of the study. This is followed by the materials and methods in Section 2. Section 3 presents descriptive and inferential statistics from the data analyses carried out. Section 4 covers the discussion and future recommendations. Conclusions are presented in Section 5.

2. Materials and Methods

2.1. Selection and Description of the Study Area

The study was carried out in the Chris Hani and Amathole district municipalities in the Eastern Cape Province of South Africa. Three local municipalities were selected based on their agricultural activities: Emalahleni, Intsika Yethu and Ngqushwa. Emalahleni and Intsika Yethu are situated in the former Transkei, while Ngqushwa is situated in the former Ceskei homelands. The Qamata and Tyhefu irrigation schemes were chosen because they are considered to be among the largest small-scale irrigation schemes involved in crop production and still operating in the selected local municipalities. Farmers grow a variety of crops, including field crops and vegetables such as maize, cabbage, potatoes, butternut, carrots and spinach. Maize is the staple crop among the black population, and cabbage is the most frequently consumed vegetable. In addition, the irrigation schemes were found to be suitable for the study because they are located in different former homeland areas with characteristics that are representative of the dominant conditions in the province. Such an analysis is crucial for determining the stages of development for each scheme. The former Transkei and Ciskei are predominantly associated with poverty and high unemployment levels [38]. The former Transkei represents a more rural environment, while the other incorporates urban and peri-urban environments, with corresponding occupational patterns. There are significant historical differences between the two areas; hence, this allows for a comparative analysis. The study areas also allowed for the representativeness of the sample in terms of the production technologies since they include farmers who participate in irrigation and those practising home gardening. Figure 1a,b show maps of South Africa and the Eastern Cape Province, respectively.

(**a**) Map of South Africa



(b) Map of Eastern Cape Province

Figure 1. (**a**) Map of South Africa; (**b**) map of Eastern Cape Province.

2.2. Research Design

2.2.1. Theoretical Framework

The study is simultaneously modelling profits and food security for the same sample to examine the factors influencing both variables, with a focus on the area under cultivation. Two strands of relationships require a special technique to model in one step, where the dependent variables are assumed to be independent of each other. Two crops, cabbage and maize, are under investigation, and two profit equations were generated. Income from crop production is used to assess the food security status of households. Hence, the study uses a multiple equation structure, which makes the Seemingly Unrelated Regression Equations (SURE) an appropriate method of analysis. According to Arnold Zellner's 1962 approach [39], SURE can be presented as follows: Suppose there are m regression equations:

$$y_{ir} = x^T \beta_i + \varepsilon_{ir} \tag{1}$$

where i represents the equation number $1 \leq i \leq m$, $1 \leq r \leq R$ is the observation index and ^{T} represents the transpose of the x_{ir} column vector. The number of observations R is assumed to be large, so in the analysis we take $R \to \infty$, whereas the number of equations m remains fixed. Each equation i has a single response variable y_{ir}, and a k_i- dimensional vector of regressors x_{ir}. If we stack observations corresponding to the i-th equation into R-dimensional vectors and matrices, then the model can be written in vector form as:

$$y_i = X_i \beta_i + \varepsilon_i \tag{2}$$

where y_I and ε_i are $R \times 1$ vectors, X_i is a $R \times k_i$ matrix, and β_i is a $k_i \times 1$ vector.

This assumes that the error terms ε_{ir} are independent across time but may have cross-equation contemporaneous correlations. Thus we assume that $E[\varepsilon_{ir}\varepsilon_{is} \mathrm{I}\, X] = 0$ whenever $r \neq s$ whereas $E\left[\varepsilon_{ir}\varepsilon_{jr} \mathrm{I}\, \mathrm{X}\right] = \sigma_{ij}$. Denoting $\sum = [\![''\sigma'' \langle sub \rangle '' ij'' \langle / sub \rangle]\!]$ the $m \times m$ skedasticity matrix of each observation, the covariance matrix of the stacked error terms ε will be equal to:

$\Omega \equiv E[\varepsilon\varepsilon T\ \mathrm{I}\ \mathrm{X}] = \Sigma \bigotimes \mathrm{IR}$, which can also be represented as:

$$\Omega \equiv \begin{bmatrix} cov(u_1, u_1) & cov(u_1, u_2) & \ldots & cov(u_1, u_R) \\ cov(u_1, u_2) & cov(u_2, u_2) & & \\ \vdots & & \ddots & \\ cov(u_1, u_R) & & & cov(u_R, u_R) \end{bmatrix},$$

where IR stands for the R-dimensional identity matrix, while ⊗ denotes the matrix Kronecker product. This model has received wide application in finance, development and agriculture [39–41]. Following Arnold Zellner's approach [39], the following system of equations was estimated simultaneously:

$$Y_1^n = \alpha + \beta_i X_i + \varepsilon_i, \text{ where } n = 3, \tag{3}$$

where Y_1 is food security based on productive farm income, Y_2 is maize profit and Y_3 is cabbage profits. $X_i's$ are the explanatory variables for each equation including farm data and socioeconomic characteristics, viz: age, gender, farming experience, income variables, education, output and input prices and dummies for location and irrigation participation.

2.2.2. Conceptual Framework

Food security remains at the centre of many governments' agenda globally [42–44]. Many countries, especially in the developing world, still face serious food security challenges, and South Africa is no exception [43]. In developing countries, the production of staple crops becomes paramount for achieving the goal of alleviating the twin problems of poverty and food insecurity [44]. Increasing demand for food in the past has been met by increasing the amount of land under cultivation, increasing productivity per unit area or both [45]. Sub-Saharan Africa was noted to have a vast amount of unutilized arable land [45].

Figure 2 gives the conceptual framework, highlighting the importance of land in crop production. Farm size determines the area under crop production. Land allocation towards crop production is driven by the objective to feed households and make profits through the sale of surplus on the market. Households that do not participate in markets consume all their produce, thereby alleviating household food shortages. Through market participation, households can sell their marketable surplus and earn additional income. An increase in disposable income enhances a household's access to other food types, consequently improving nutritional status. Farmers can also invest their profits in their farm business through innovations and new technologies, thereby enhancing productivity.

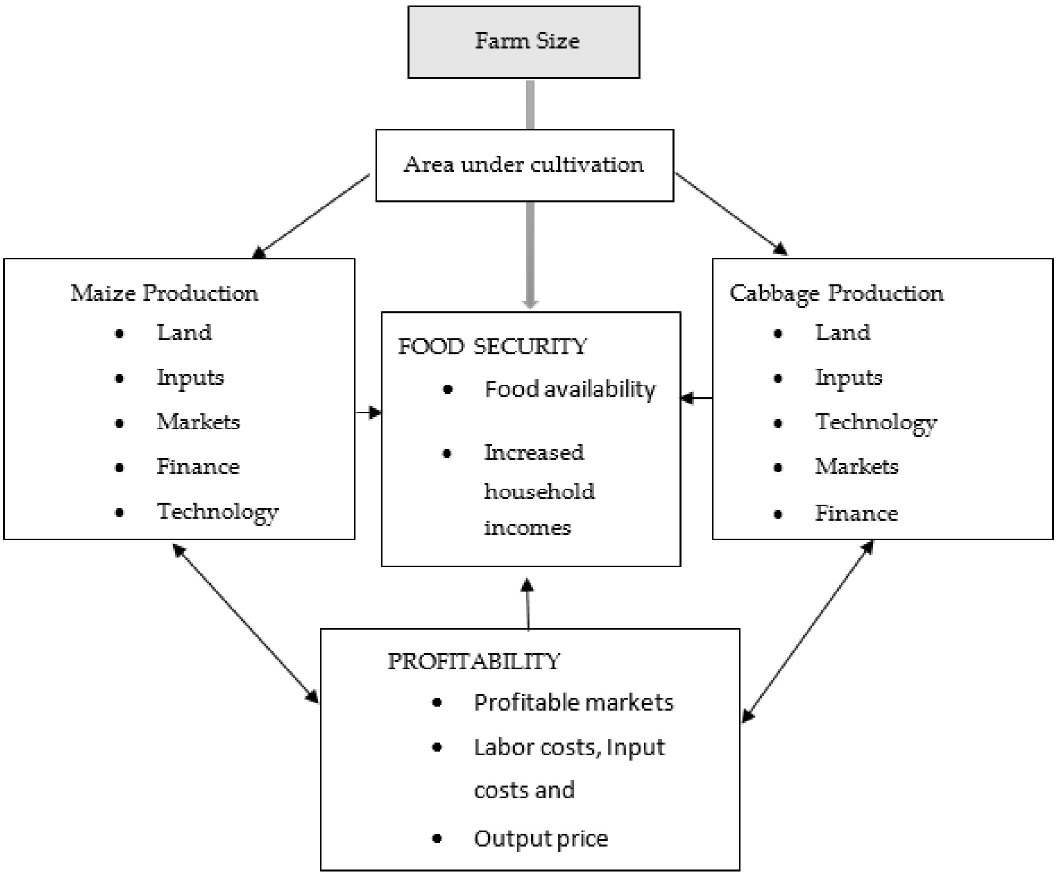


Figure 2. Conceptual framework. Source: Authors' compilation, 2017.

2.3. Sampling Techniques and Sample Determination

The study was part of a larger project that sought to formulate and test appropriate development paths for establishing sustainable farming businesses with crop enterprises to increase food security and profitability on smallholder irrigation schemes. Therefore, smallholder crop farming households were targeted. For comparative purposes, both irrigation and homestead farmers were chosen. Homestead gardens are located within the residential area in which the farmers' dwellings are situated; as part of the Apartheid regime's Betterment Programme, each black household was allocated a plot of land measuring 1.5 ha, on which the household built a home for the family and used the rest of the space for the purposes of growing crops and raising livestock. Such gardens are not part of established irrigation schemes and are generally rain-fed or watered manually by the household.

The data were obtained by means of a multistage sample survey conducted in the Eastern Cape province of South Africa. The Eastern Cape is one of the poorest provinces in South Africa and relies on staple crop production for food security, particularly in the rural parts. Three municipalities were chosen because they have suitable characteristics such as crop farming and irrigation. Purposive sampling was also used for selecting the specific study sites. Qamata and Tyhefu are both established irrigation schemes undertaking crop production. The unit of analysis was the household, and 158 households were selected using random sampling. Figure 3 presents the process of sample selection and composition.

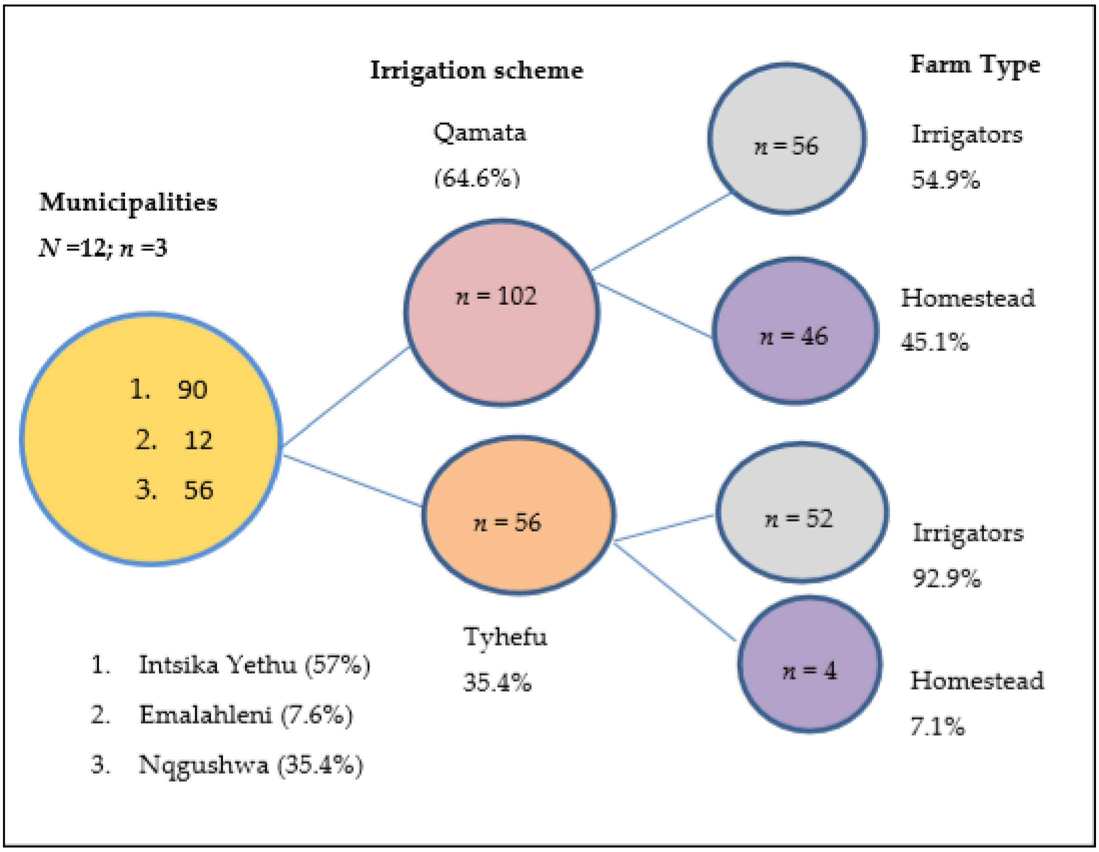


Figure 3. Sample selection and composition.

Table 1 shows the population of irrigators and homestead gardeners at Qamata and Tyhefu, along with the respective samples and sample fractions. A 9.3% sample fraction was obtained at Qamata; this is representative of the population of both farm types. Tyhefu has a different physical and demographic outlook from that portrayed by Qamata. While Qamata had a total of 675 irrigators and 450 homestead gardeners, Tyhefu had a much smaller farming population: 246 irrigators and only four homestead gardeners. In Tyhefu, landholding was through land redistribution undertaken since the end of Apartheid and only involved farmlands—in contrast with the situation in the Apartheid era, when land was allocated to serve both residential and farming purposes in more traditional areas such as Qamata, where homesteads acquired by inheritance exist within walking distance of the irrigation schemes [46]. As a result, all four homesteads that happen to be in close proximity to the irrigation scheme were enumerated The sample composition at a municipal level is as follows: Intsika Yethu (n = 90, 57%), Emalahleni (n = 12, 7.6%) and Nqushwa (n = 56, 35.4%). Qamata irrigation scheme and surrounding villages had the highest sample (n = 102, 64.4%) and Tyhefu (n = 56, 35.4%).

Table 1. Distribution of sample size.

Category	Qamata Area			Tyhefu (Ndlambe) Area		
	Population (N)	Sample Size (n)	Sample Fraction (%) (n/N)	Population (N)	Sample Size (n)	Sample Fraction (%) (n/N)
Irrigation	675	56	8.3	246	52	21.1
Homesteads	450	46	10.2	4	4	
Total	1125	102	9.3		56	

Source: Survey data, 2017.

2.4. Data Collection

Data were collected by means of a closed-ended questionnaire administered in structured interviews in the local IsiXhosa language. The questionnaire was pretested in Melani Village, which has agricultural activity similar to the study sites and is easily accessible from the University. Following the pretesting phase, the questionnaires were revised and finalized. The actual field survey consisted of single-visit interviews with household heads selected by the processes described in the previous sections. The field survey took place in January–April 2017 when the weather was warm and before the onset of Southern Hemisphere Winter in the Eastern Cape Province. The survey data included information about crop production, farm size and marketing activities, as well as household demographic characteristics. Table 2 presents a description of the variables used in the study.

Table 2. Variable description and measurement.

Variable	Description and Unit of Measurement
Age	Age of household head in years
Household size	The number of persons permanently living within a household
Gender	Gender of household head: Male = 1; Female = 0
Farming experience	Number of years in farming of household head
Years in school	Number of years spent in school by household head
Nonfarm income	Income derived from nonfarm labour activities in Rands
Total income	Total household income; includes farm income, remittance and nonfarm income (Rands)
Access to extension	Does household head have access? Yes = 1; No = 0
Remittance	Income from relatives working in the city plus grants (Rands)
Farm income	Income generated from farm activities (crop and livestock) (Rands)
Irrigation	Dummy variable of participation Yes = 1; No = 0
Farm size	Total area (hectares)
Labour	Cost of hired labour (Rands)
Price of maize	Selling price of a single maize cob in Rands
Price of cabbage	Selling price of a single cabbage head in Rands
Price maize fertiliser	Price of fertiliser used on maize per kg in Rands
Price cabbage fertiliser	Price of fertiliser used on cabbage per kg in Rands
Area maize	Area under maize cultivation in that season (ha)
Area cabbage	Area under cabbage cultivation in that season (ha)
Location	Dummy variable for location; Qamata = 1, Tyhefu = 0

2.5. Data Analysis

The factors influencing food security and crop profits were estimated using a system of seemingly unrelated regressions. The three empirical equations are specified as follows:

$$Food\ security = f\begin{bmatrix} farm\ income,\ maize\ output,\ age\ squared,\ household\ size,\ gender, \\ access\ to\ extension,\ farm\ size,\ location,\ total\ income,\ irrigation \end{bmatrix} \quad (4)$$

$$Maize\ profit = f\begin{bmatrix} age\ squared,\ years\ in\ school,\ labour\ income,\ maize\ price \\ labour,\ farm\ size,\ area\ under\ maize,\ fertiliser\ price \end{bmatrix} \quad (5)$$

$$Cabbage\ profit = f\begin{bmatrix} loction\ farm\ income,\ total\ household\ income,\ labour \\ area\ under\ cabbage, fertiliser\ price, farming\ experience \\ years\ in\ school, access\ to\ extension, credit\ access, irrigation \end{bmatrix} \quad (6)$$

Equation (4) shows the estimation of household food security. The food poverty line approach was used to determine household food security status [47]. Households with incomes falling below the food poverty line were considered to be food-insecure (Y = 0) and incomes on and above the poverty line were considered to be food-secure (Y = 1) [48,49]. The food poverty line approach has received wide application in developing countries. Despite the popularity amongst researchers and development practitioners, poverty lines have been criticized for being ill-suited to household dynamics in South Africa, such as intrahousehold distribution of income.

The dependent variables in Equations (5) and (6) were derived using gross margin analysis. Gross margin, which is the return over variable costs, is an appropriate measure to use for comparing enterprises that make identical demands upon limited resources of farmers, for short-run and annual planning decisions. Gross margin refers to the gross income minus the variable costs associated with an enterprise or activity. Gross margins were estimated on IBM SPSS Statistics for Windows version 25,(Armonk, New York: U.S.A), by using Equation (7):

$$GM_i = TR_i - TVC_i, \quad (7)$$

where TR_i is the total revenue from production of crop $\boldsymbol{i}$ and TVC_i is the total variable costs from the production of crop $\boldsymbol{i}$. Total revenue from each crop was calculated as the total quantity sold multiplied by the output price. Variable costs in the study emanated from the employment of labour and use of fertiliser and seeds. Total variable costs were calculated using Equation (8):

$$TVC = \sum\nolimits_{i=1}^{2} (K_{i,t} + S_{i,t} + L_{i,t}), \quad (8)$$

where $K_{i,t}$ is the fertiliser expenditure, $S_{i,t}$ is the total expenditure on seed and $L_{i,t}$ is the total labour expenditure on each enterprise.

The estimations were conducted by means of the *R* (R Core Team, Florida, U.S.A 2014) and *Stata* (*Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.*) softwares. Covariances of the estimated equations were run using Stata 15. The variances of the variables depicted diagonally in the covariance matrix are important for outlining how the dependent variables vary from the mean. The system correlations and covariances were presented in tabular form. Pearson correlations were carried out for continuous variables, whilst Spearman's correlations applied to categorical variables. Although separate tables of the pairwise correlations are not presented, both are discussed in the following section.

3. Results

3.1. Socioeconomic Profiles of Farmers

The most frequently observed gender was male (n = 103, 65%). The most frequently observed age group was over 60 (n = 82, 52%). The most frequently observed level of education was primary school (n = 62, 39%). The most frequently observed primary occupation was farming (n = 145, 92). Most farmers had 0 to 10 years of farming experience (n = 98, 62%), which is part of the legacy of Apartheid, during which most adult males worked in the mines to earn wage income rather than in agriculture, which was dominated by white farmers whose superior production technology put the black population at a disadvantage. However, with the end of Apartheid and the launch of the land reform programme, which coincided with reductions in mine employment due to rising labour costs that have occasioned large-scale retrenchments, farm employment has grown among the black population. The most frequently observed income group is R5001–10,000 per annum (n = 82, 52%). The frequencies and percentages of the aforementioned characteristics are presented in Table 3.

Table 3. Socioeconomic characteristics of respondents (n = 158).

Variable	Frequency (n)	Percentage (%)
Gender		
Male	103	65
Female	55	35
Age		
30–40	13	8
41–50	18	11
51–60	45	29
Above 60	82	52
Educational Level		
None	48	31
Primary (1 to 7 y)	62	39
Secondary (8 to 12 y)	35	22
Tertiary (13 y or more)	13	8
Primary Occupation		
Farming	145	92
Other	13	8
Farming Experience (years)		
0–10	98	62
11–20	31	20
21–30	17	11
31–40	5	3
41–50	7	4
Annual Income		
<1000	5	3
1000–5000	46	29
5001–10,000	82	52
10,001–15,000	9	6
Above 15,000	16	10

Source: Field survey, 2017.

The observations for the maize enterprise had the following mean and standard deviation: profits R2213 (SD = 1476), area 0.7 ha (SD = 0.70) and fertiliser 40.93 kg (SD = 41.19). The cabbage enterprise observations had average profits of R830 (SD = 2531), average area under cultivation 0.1 ha (SD = 0.198), average fertiliser 8.30 kg (SD = 21.5). The income observations had the following statistics: Remittances mean R3609 (SD = 3601), nonfarm income mean R4090 (SD = 3473), farm income mean R3470 (SD = 4025) and total income mean R3470 (SD = 4025). The observations for age had an average of 61 (SD = 12.54), farm experience 12 (SD = 12), years in school 5 (SD = 4.45). Table 4 shows the summary statistics of the variables used in the study.

Table 4. Summary statistics.

Variable	Mean	SD
Maize profit (Rands)	2213	1476
Cabbage profit (Rands)	830	2531
Age	61	12.54
Farming experience	12	12
Years in school	5	4.45
Remittance	3609	3601
Nonfarm income	4090	3473
Farm income	3470	4025
Total income	11,169	6122
Total area	0.80	1.01
Area—maize	0.7	0.70
Area—cabbage	0.1	0.20
Fertiliser—maize	40.93	41.19
Fertiliser—cabbage	8.30	21.5
Yield per hectare (kg/ha)		
Maize	1037.14	
Cabbage	5983.19	

Source: R generated the results from survey data, 2019.

3.2. Factors Affecting Food Security and Farm Profits

The food security variable used in the SUR model was derived from labour income, which consists of both agricultural and non-agricultural activities. The objective here was to find out if farmers can sustain their food security status from labour income, which they derive on and off the farm. The results of the maximum likelihood estimation are presented in Table 5.

Table 5. Factors affecting food security and profits using the Maximum Likelihood (ML) technique.

	Coefficient	Z	$P > \|z\|$
Food security			
Total farm income	0.0008	15.46	0.000 ***
Maize output	−2.66e-06	−0.37	0.714
Age squared	−0.00001	−1.23	0.217
Household size	−0.002	−0.37	0.715
Gender	0.04	1.35	0.176
Access to extension	0.005	−0.19	0.853
Farm size	0.019	−0.99	0.324
Location dummy	0.142	3.63	0.000 ***
Total income	−6.60e-06	−2.23	0.026 **
Irrigation dummy	−0.118	−3.40	0.001 ***
Maize profit			
Age squared	0.074	1.07	0.283
Years in school	13.136	0.5	0.617
Total labour income	−0.011	−0.44	0.659
Price of maize	595.434	4.23	0.000 ***
Labour	−1.511	0.13	0.896
Farm size	1651.27	−4.07	0.000 ***
Area under maize	−950.969	3.02	0.002 ***
Price of fertiliser	1.413	−1.72	0.086 *
Cabbage profit			
Location dummy	85.878	0.38	0.702
Total farm income	0.128	2.96	0.003 ***
Total income	−0.008	−0.32	0.745
Area under cabbage	12265.22	13.87	0.000 ***
Price of fertiliser	−190.35	−9.19	0.000 ***
Farming experience	−11.436	−1.12	0.262
Years in school	0.515	0.02	0.986
Access to extension	165.538	0.66	0.507
Credit access	−230.060	−0.49	0.625
Labour	−0.552	−1.23	0.218
Irrigation dummy	−77.578	−0.25	0.805
Diagnostic statistics			
Equation	RMSE	R^2	P
Food security	0.18	0.74	0.00
Maize profit	1254.88	0.78	0.00
Cabbage profit	1520.77	0.68	0.00

Source: Stata generated the results from survey data (2019). Significance levels ***, **, *: 1%, 5% and 10%, respectively.

Nonlabour income, mainly comprised of social grants and remittances, forms a large part of household income and contributed about 28% to total household income. From the food security model, it can be noted that both income variables were significant. Total farm income was significant at the 1% level, whereas total household income was significant at the 5% level. A Pearson correlation of 0.81 between total farm income and food security shows that farm income contributes immensely to food security. Farm income explains 65% of the variability in household food security. Household income has a weaker positive relationship to food security of 0.38. The dummy variables for irrigation and location are significant at the 1% level. Location is negatively correlated at −0.15, and irrigation is positively correlated at 0.08, with household food security using Spearman's correlation coefficient.

However, both correlations are weak, implying that a move towards irrigation, for instance, has a positive but small impact on food security; moving a farmer from the Qamata scheme to the Tyhefu irrigation scheme would lower food security status by a negligible 2.3%.

Maize is extensively produced in the study area compared to other crops. The output price for maize and farm size was found to highly influence maize profits at the 1% level of significance. According to a gross margin analysis, a higher price for maize, *ceteris paribus*, results in an increase in the gross margin. A high and positive correlation of 0.98 was found between farm size and area under maize cultivation. This implies that, if farmers take up more land that is apparently lying idle on most irrigation schemes, then they would also increase the area under maize cultivation. Hence, more maize output, holding prices constant, leads to higher gross margins.

Price of fertiliser was highly significant at the 1% level. A positive but weak relationship was observed with a Pearson's correlation coefficient of 0.85. Cabbage has been identified as a potentially profitable crop of commercial sale due to its high yield per hectare in the study area. Increasing fertiliser consumption in cabbage production would increase production and consequently farm profits. Total farm income was also found to be an important variable in determining cabbage profits; the variable is significant at the 1% level. Farmers need to purchase inputs for cabbage production; hence, farm income is reinvested into the farm enterprise. An increase in farm income leads to the timely purchase of inputs and other implements vital for production. This results in increased production, leading to higher gross margins, *ceteris paribus*. While this may be obvious, it carries special significance for the project area in the proximity of which declining farm incomes within a farming community may have contributed to a drastic reduction in the farming population, with many farmlands being abandoned [50,51]. A positive Pearson correlation coefficient of 0.40 between income and profits supports this notion. However, this only explains 16% of the variability, meaning there are other relevant but unobserved factors affecting profits. In addition, the area under cabbage production also determines the number of cabbage heads that can be grown. The larger the area, the more output can be harvested. The average area under cabbage production is 0.1 hectares. Increasing the area by a unit of 1 hectare leads to a 40% increase in cabbage profits, as shown by a Pearson correlation coefficient of 0.63. There is a lot of potential within the cabbage enterprise and farmers need to be fully abreast of innovations and market dynamics in order to realise the benefits. The covariance matrix of the residuals are presented in Table 6. The correlations between income variables and food security show the strength and direction of relationships amongst the variables and are presented in Table 7.

Table 6. The covariance matrix of the residuals.

	Food Security	Maize Profits	Cabbage Profits
Food security	0.03	8.99	0.31
Maize Profits	8.99	87871.90	−84.61
Cabbage Profits	0.30	−84.61	696.52

Source: R generated the results from survey data (2019).

Table 7. Correlations of the residuals.

	Food Security	Maize Profits	Cabbage Profits
Food security	1.00	0.17	0.06
Maize Profits	0.17	1.00	−0.01
Cabbage Profits	0.06	−0.01	1.00

Source: R generated the results from survey data (2019).

The covariances in Table 6 show the direction of linear movement among the dependent variables. They depict a positive relationship except for maize and cabbage profits, which are negatively related. The diagonal of the matrix is the variances, which show how much data are scattered around the mean. The sample variance of 0.03 for food security shows that data points are close to the expected mean and hence to each other. In other words, there is not much variation across households in terms of food security. However, there is substantial variation across households in the cabbage and maize enterprises. These large variances can be accounted for by farm type (irrigation or homestead), farm size, off-farm activities and resource allocation [52]. To show the strength of the linear relationships, the correlations of the residuals were tested and the results are presented in Table 7.

The correlations between maize profits and food security as well as cabbage profits and food security show positive but weak relationships, as shown in Table 7. For instance, increasing maize profits by a unit would result in a mere 3% improvement in food security. The correlation coefficient for cabbage and maize profit is negative and small. The negative correlation between cabbage and maize profits indicates that the two crops compete for resources such as land, irrigation, labour and others, which is not surprising given the existing integrated structure of the family farm in the study area. To increase maize production, resources would be transferred from cabbage production to maize production. However, an increase in output for maize leads to a negligible decrease in cabbage output. Therefore, policies favouring the commercialization of both crops would introduce incentives to promote and increase production in the study area.

4. Discussion and Recommendations

The aim of this paper is to examine the factors influencing farm profits and food security, with an emphasis on cultivated area. The socioeconomic characteristics of respondents in the study show a male dominance in agriculture. The majority of farmers are older, with the average age being 61 years. Farming is the primary occupation in the area and most farmers are uneducated. A high level of illiteracy poses high adjustment costs to farmers because they lack the skills for industry jobs. With the majority of farmers practising full-time subsistence farming, there are no additional sources of labour income, resulting in very low annual incomes for rural dwellers. All these variables have important implications for policy. Youth participation in rural crop farming is very limited; this implies that crop production may become a thing of the past in the near future [53]. Deagrarianization has already been observed in parts of the Eastern Cape Province [51]. Rural crop production plays a major role in alleviating food shortages in most developing countries. Rural development should be at the core of the government agenda since the majority of households still derive livelihoods from agriculture. The state of rural farming is appalling and repels youth participation. According to the Pew Research Center, anyone born between 1981 and 1996 (ages 23 to 38 in 2019) is considered a Millennial, and anyone born from 1997 onward is part of a new generation. Governments need to keep in mind the characteristics of these new generations of farmers when formulating policies for rural development. Such policies should include smart agriculture practices with the use of advanced technologies and innovations. Hence, sizeable investments in research and development are necessary. This results in rural agricultural transformation, an increase in productivity and the creation of jobs, all of which will have positive effects on rural–urban migration.

The realised and expected yields per hectare for both crops are very low compared to the regional outcomes. The FAO [54] reports that Zimbabwe, Zambia and Malawi attained irrigated maize yields of 8000, 5300 and 5500 kg/ha, respectively. Similarly, cabbage yields reached 23,900 kg/ha in Zimbabwe [54]. The study sites attained yields of 1037.14 kg and 5983.19 kg per hectare for maize and cabbage, respectively. The mean nitrogen fertiliser application for maize in the study area was 40.93 kg. The application was very low compared to other developing countries such as Indonesia, whose mean application was 120 kg per hectare. According to the Department of Agriculture, Forestry and Fisheries [55], cabbage production in South Africa requires 200 to 250 kg of nitrogen per hectare. The average amount of fertiliser applied to cabbage in the study area was about 8.30 kg/ha, implying that fertiliser is barely applied. The average years of schooling was five and the sample was dominated by farmers aged 61 or over. These two variables have adverse effects on technology adoption and overall farm productivity. The study revealed that off-farm labour income is the highest source of income. However, less than 10% of the farmers are involved in off-farm income-generating activities, as shown in Table 3.

The summary statistics in Table 4 show that maize attained higher profits than cabbage, with a mean of R2 213. This is supported by the higher acreage of maize. The average area under maize cultivation is 0.7 hectares and for cabbage it is 0.1 hectares. Even though maize attained higher profits, the yields per hectare values are lower. Cabbage has a potential of attaining 5983 kg per hectare as compared to maize with 1037 kg per hectare, implying that cabbage has the greater potential to generate more income. It can be argued that cabbage production enjoys a comparative advantage over maize production in the study area. Therefore, the commercialization of cabbage production would yield higher profits for farmers. Comprehensive market analysis is needed to complement the production studies that have been conducted in these areas for making more informed decisions about the optimal strategy for the commercialization of crop enterprises. Markets can be local, regional or international, and a lot of infrastructure needs to be in place. Linking farmers to profitable markets would ensure sustainable production and the alleviation of rural poverty.

This is an interesting result considering that maize is more popular in the diet than cabbage since it is the staple crop of the country. Farm income is a major determinant of food security and cabbage profits. The positive cross-equation correlations are also interesting. There is a positive correlation with a coefficient of 0.17 between the random error that determines food security and the corresponding errors of maize production. Policies in favour of maize production will significantly alleviate food insecurity. In the case of food security, irrigation adoption and commercialization within the smallholder context in South Africa, there remains a lot of work to do. In terms of food security, more work needs to be done on the intrahousehold distribution of resources. Such an analysis would help in more precisely determining the food security status of individuals within a household and understanding issues of malnutrition, which can manifest selectively within a household.

Thus, farmers should increase the area under cabbage production relative to maize production because cabbage seems to be more advantageous in terms of resource use. The area under cultivation was found to be significant for both crops. Maize is the staple crop in the province and is mainly processed into mealie meal for pap or samp for the traditional dish *umngqusho*, or eaten unprocessed as corn. Cabbage is a vegetable mainly used for salads. It makes economic sense to reduce the area under maize production and increase that under cabbage production, as maize production is mainly for household consumption. Commercializing cabbage production has the potential to generate higher profits for rural households. Extension services should play a major role in building capacities for farmers to adopt innovations to boost production [56].

A negative correlation (−0.01) exists between residuals that determine maize and cabbage production. This implies that the two crops compete for resources. A 0.01% level effect size should not be a cause for concern as it reflects minimal impact. However, there is a need for resources to be optimally allocated to avert leakages in the production line emanating from inefficiencies. Cultivated area is highly significant for the production of both crops. In light of that, farmers need to adopt new technologies and be fully aware of the associated benefits.

5. Conclusions

For low-income households at risk of hunger, an overriding policy concern may be to provide resources and initiatives for increased production. For instance, land rights and initial support with irrigation schemes to incentivise farmers to adopt irrigation technology should be considered. Support can come in the form of input acquisition, fertiliser application and marketing of produce. In order to attain sustainable food security, in the absence of a strong credit market, full-time farming is not a feasible option; farmers need to engage in off-farm income-generating activities to augment their farm income. Allocation of resources towards non-agricultural activities should augment household income to achieve a successful transformation. Most importantly, rural transformation will not be complete without the active participation of the youth. Making agriculture smart is one way of attracting youth to this sector. Establishing innovation hubs within rural centres would lead to a strengthening of rural entrepreneurship and youth employment.

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