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Profitability of cabbage production by smallholder farmers in the Eastern Cape Province, South Africa

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ABSTRACT

Cabbage is one of the most cultivated vegetable crops that are used as a staple crop because of its affordability and nutritional value. Improving profit efficiency in vegetable farming is important for both economic, livelihood, and to certain extent - food security. The crop plays a significant role in reducing the poverty levels of the previously disadvantaged in different parts of South Africa. We argue that cabbage is mostly grown by smallholder farmers whose technical efficiency is not well known. It is for this reason that we take measures towards developing empirical evidence on technical efficiency to enhance its production and advancement. The study estimated technical efficiency and factors of technical inefficiency among smallholder irrigation producers of cabbage. A total of 150 growers were selected from a list of vegetable farmers from Eastern Cape Municipalities using a multi-stage sampling. A stochastic production frontier model was employed while correcting for heteroscedasticity in stochastic and inefficiency error terms. Gross margin was used to determine the profitability of smallholder cabbage farming.

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The study findings revealed that farming is practiced by the elderly who mainly had primary education. There were increasing returns from cabbage farming and farmer average technical efficiency of about 78%. This implies 21.16% inefficiency level, indicating that there are reserves available to raise revenues through refining practical and allocative competencies of farmers. Farm size (Area), seed and capital were production-increasing variables while fertilizer and labour used were reducing farm returns of cabbage production. Sources of farmer technical inefficiency were age, farm experience, years spent in school, access to extension services, household size and transportation to markets. The provision of formal skills development training and resources for farmers could improve the technical and managerial capacities of farmers.

Keywords: Cabbage farming, Eastern Cape Province, Profitability, Smallholder irrigation, Stochastic Frontier

1. INTRODUCTION

Vegetables are a healthy diet since they contain many of the nutritional values such as protein, inorganic salts, vitamins, vitamins, aromatics, iron, and essential oils. Thus, they are identified as a good contributor to a balanced and healthy diet (Bvenura and Sivakumar, 2017). However, vegetable production and marketing systems face many challenges like lack of storage, transportation, packaging and value addition. For instance, vegetables are highly perishable and require better methods of preservation such as storage throughout the value chain (Siddiq and Uebersax, 2018). Cabbage is a vegetable crop that is grown worldwide, of which African countries are no exception. In South Africa, the production of leafy vegetables is dominated by smallholder farmers whose productive activities are constrained by socio-economic, institutional, resource and environmental factors. The authors acknowledge that cabbage production is an imperative source of employment for smallholder vegetable farmers, contributing towards households’ food and nutrition security and income generation, leading to poverty alleviation. Cabbage has been classified as discreetly vulnerable to water stress, with the head formation period being more sensitive. It is for this reason that when producing cabbage, an adequate supply of water and good water management practices must be maintained as measures of obtaining high yield and good quality produce.

The South African government has made efforts to revitalize irrigation schemes as an approach to change and improve agricultural outputs (Zuma, 2012). This approach has yielded results as the status of irrigation schemes has increased immensely as agricultural production in the Eastern Cape province through irrigation schemes. Most these irrigation schemes utilize drip and sprinkler irrigation. The type of irrigation differs among farmers due to cost of purchasing the inputs. Because of inconsistencies experienced by vegetable farmers and efforts made, innovation and adoption of new technologies such as irrigation farming is an appropriate method enhancing smallholder production, reducing poverty and restoring livelihood to smallholder farmers.

However, the participation of smallholder farmers in market-oriented production has potential for income diversification and an increase in agricultural productivity, hence encouraging profitability, food security and poverty reduction. Imperfections in markets and asymmetric market price information hinder the potential gain that could have been reached under the existence of markets with complete information. In this regard, marketing vegetable crops is the major challenge that smallholder farmers are facing which deters their farm profitability. Along with several farming challenges, market participation has failed to be transformative. Consequently, economic welfare of these farmers has declined due to low agricultural productivity, and little has been done to quantify their profitability and to improve their livelihoods. The causes of the varying profits and efficiency have not been empirically established. This study assumes that limited resource mobilization and allocation is the main reason affecting vegetable productivity in the province. Therefore, the objective of this study was to examine the profit efficiency of smallholder cabbage producers under irrigated agriculture in the Eastern Cape Province.

2. LITERATURE REVIEW

Water availability is the main restrictive factor for smallholder farming in Africa. Africa and the Middle East have experienced a high poverty reduction, increased food security and employment

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because they established large proportions of irrigation land for cultivating crops and vegetables. Kibirige *et al*. (2019) state that the establishment of irrigation schemes in regions (especially in semi-arid areas) where they are prone to prolonged droughts in the pastoral communities is viewed as one of the expansion pathways to increase agricultural productivity and enhanced livelihoods.

South Africa is a water-stressed country and this affects farming. Farming is facing challenges such as water availability and changing global climatic conditions. Thus, smallholder vegetable and crop production is declining because of water availability as a result of prolonged drought. Beshir (2017) and Sitta (2011) specify that an additional 80% of water resources have been demoralised for agricultural irrigation. To cope with the water shortage, it is necessary to adopt water-saving agricultural counter-measures and that is the use of irrigation water efficiently as is becoming increasingly important in enhancing productivity. On realisation of water scarcity in South Africa, many irrigation schemes were established in the former homeland's areas such as Eastern Cape, Limpopo and KwaZulu-Natal Provinces during the 1960s and 1970s. However, most of the established irrigations schemes were unsustainable due to several challenges (Van der Horst and Hebinck, 2017). In the quest to recuperate the failed irrigation schemes, the government of South Africa boarded on the revitalisation of these schemes, which began in 1994 through the introduction of canal irrigation schemes. According to DAFF (2015), irrigation schemes were established purely to stimulate economic growth and rural development. On realising the farmers' challenges, the South African government has continued its efforts and quests of revitalising irrigation schemes as they see them as the only way to save water efficiently and to expand agricultural productivity to increase food security and reduce poverty in rural areas.

Cabbage is a vegetable crop that has been classified as vulnerable to water stress, with the head development period being more delicate than the period before in its development. Cabbage production requires more water for growth as the most critical irrigation period for cabbage is occurring during the last 3 to 4 weeks before harvest. Given the water limitation that smallholder farmers are limited to, the productivity of cabbage is declining because of water shortages. To attain optimal cabbage, production and also assign limited water resources appropriately, cabbage should be irrigated daily and in the evening. Smallholder irrigation is the only strategy that can increase cabbage production as it uses water more efficiently. Farmers practise irrigation since cabbages require an abundant and well-distributed water supply to enhance productivity and income returns respectively. Cabbage production must be produced efficiently.

This paper defines technical efficiency as the ability of the farm to produce a maximum level of cabbage output given a similar level of production inputs while allocative efficiency is defined as producing output with the minimum cost of production to attain maximum profits. Economic efficiency is a product of both allocative and technical efficiency and it is attained when the producer combines resources in the slightest grouping to produce supreme output as well as conserving the smallest cost to obtain maximum revenue. Therefore, it is imperative to increase cabbage productivity and profitability.

3. METHODOLOGY

3.1 Study Area

The study was carried out in the Eastern Cape Province, the third most populated province in South Africa with 6 562 053 (12.7%) after Gauteng and KwaZulu Natal Province, which are estimated to have populations of 12 272 263 (23.7% of national) and 10 267 300 (10.8%) respectively (Mdoda and Obi, 2019; DEDEAT, 2013; Hlomendlini, 2015). The province is having 5 Districts and 2 Metropolitan Municipalities. The average poverty level of the province is estimated at 74.9% and the province's level of food insecurity (78%) is above the average national level of 64% (Mdoda and Obi, 2019; DEDEAT, 2013). The province is characterised by the high levels of food insecurity and about 78% of the province’s households are classified as food insecure (Mujuru and Obi, 2021). Most of the dwellers in the Eastern Cape derive their livelihoods from agriculture. Hlomendlini (2015) states that a large percentage of households in the province are involved in farming and in most cases, they are not farming for business and income. Rather, they are practising farming to supplement other income sources and for household purposes. The study adopted a cross-sectional survey design where the data were collected at one point in time (meaning collecting data once) with the use of structured questionnaires.

Figure 1: Map showing study sites

3.2 Sampling procedure and sampling size

The study made use of qualitative approach. A population is a discrete group of individuals comprises of a nation or a group of people with a common characteristic. For this study, the population sample was comprised of cabbage producers in the irrigation scheme. A list of cabbage producers was obtained from extension officers and farm organizations. Unit of analysis were smallholder cabbage farmers. The study was undertaken in the Eastern Cape Region of South Africa within three Districts of the province whose irrigation schemes are fully functional. A multi-stage sampling was used to select study area. First stage, three districts were selected and namely: O.R Tambo, Chris Hani and Amathole District. Second stage, one municipality was chosen in each district, namely Mhlontlo in O.R Tambo, Intsika Yethu in Chris Hani and Ngqushwa in Amathole based on irrigation availability and functionality. Last stage, smallholder cabbage producers were selected randomly from the wards within local municipalities to form the desired sample size. These Districts are well-known for their large areas of good crop land and great soils suitable for crop productivity as well as livestock farming. A multi-stage sampling procedure was employed by which smallholder irrigation schemes in the Eastern Cape were purposively selected due to their contribution to household welfare and within which 150 cabbage farmers were enumerated.

TABLE 1: Sample selection

Province	**District Municipalities**	**Local Municipalities**	**Irrigation schemes**	**Cabbage Farmers**
Eastern Cape	O R Tambo	Mhlontlo	Ntshongweni	50
	Chris Hani	Intsika Yethu	Qamata	50
	Amathole	Ngqushwa	Tyefu	50

Source: Field Survey, 2017

3.3 Data collection

The study made use of quantitative method. Primary data was the instrument used to collect data from smallholder cabbage farmers between March 2016 to November 2017 using pre-tested structured questionnaires administered by trained enumerators. The questionnaire was pre-tested in Ntselamanzi in Alice and this village did not form part of the study. The questionnaire included precise questions regarding production, marketing and farm profitability in agriculture. Information collected was on demographic, institutional, physical socioeconomic factors and marketing of the output. Additional information was collected as well such as land, labour, price of tractor times and resources usage such as manure and seed. In addition, face-to-face meetings with the respondents were held to attain in-depth information essential to realise the study's main objective. Secondary data were extracted from various sources for this study including scientific publications, annual government reports and other internet sources. These data were useful for comparison with survey data and to improve the questionnaire results to validate the survey. The field data was subsequently cleaned and coded in a worksheet to simplify access for STATA 15 and SPSS for analysis.

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3.4 Data

This section represents the demographic characteristics that were considered for the study. The variables were selected based on the consultation of specialists and relevant personnel working in the study area and related issues.

TABLE 2: Data collected

Dependent Variable	**Definition**	**Value**	**Hypothesized Relationship**
GINC	Gross Farm Income	Continuous	
Independent Variable	Definition	Value	
AGE	Age of the household head	Continuous	+/-
YRSPSCHL	Years spent in school by household head	Continuous	+/-
TOPCBBE	Cabbage production in Kg	Continuous	+
MART	Marital status of household head	A dummy variable coded 1 if married, 0 otherwise	+/-
LAND	Area cultivated by farmer in hectares	Continuous	+
FEXP	Farming experience of the farmer	Continuous	+
IRR	Use of irrigation	A dummy variable coded 1 if irrigate, 0 otherwise	+
EXT	Whether a farmer have access to extension services	A dummy variable coded 1 if access to extension services, 0 otherwise	+
FERT	Expenditure of fertilizer in Rands	Continuous	+
SEED	Expenditure of seeds in Rands	Continuous	+
LABOR	Expenditure of	Continuous	+

	labourers in Rands		
CAPITAL	Capital usage, whether farmer used tractor and machinery	A dummy variable coded 1 if farmer use tractor and machinery, 0 otherwise	+

Source: Field Survey, 2017

3.5 Data analysis

The collected data was coded and entered into an Excel spreadsheet, then, transported to Statistical Package for Social Science (SPSS) version 24 and STATA 15. This section explores 2 types of data analysis. Firstly, the descriptive statistics like frequencies, percentages as well as mean values were calculated to summarise the farmers' profiles and characteristics in the study area and stochastic profit frontier to measure practical competence of cabbage invention in the study area.

3.6 Stochastic Profit Frontier

This study applied stochastic profit frontier to measure the technical efficiency of cabbage production in the study area. The analytical techniques used in this study include stochastic frontier profit, which is in linewith Ojo et al. (2009) and Oguniyi (2008) as they adopted this model to hypothesize a profit function which is assumed to act in a routine which reliable with the stochastic frontier concept. The profit frontier model begins by considering a stochastic profit function with a multiplicative commotion term of the form in equation (1).

$$\Pi = f(p_i Z_{ik} \beta_i) e(E_i) \quad \ldots 1$$

Where

π= normalised profit defined as gross revenue less variable cost divided by the price of output

Pi = normalized price of variable inputs by the farm divided by output price

Zi = level of kth fixed factor on the farm

βi = vectors of parameters

ei = error term used

Ei = stochastic disturbance term consisting of two independent elements v and u.

Where,

$$E_i = V_i + U_i \qquad (2)$$

V_i is NID (0, δ 2) while U_i is the one-sided disturbance form used to represent profit inefficiency and it is independent ofV_i.

The stochastic profit function model can be used to investigate cross-sectional data. Concurrently, the model estimates the individual profit efficiency of the respondents as well as the determinants of profit efficiency. The frontier of the farm is given by combining equations 1 and 2 as presented in equation (3).

$$\Pi = f\left(p_i, Z_{ik,}\beta_i\right) e^{u+v} \qquad (3)$$

The profit efficiency of an individual farmer is distinct as the ratio of projected authentic profit to the predicted maximum profit for a best practical vegetable farmer and this is represented in equation (4).

$$\text{Profit efficiency } (\text{E}\pi) = \frac{\Pi}{\Pi^{max}} = exp\,\frac{\exp\{\Pi(p,E)\}\exp(lnV)\exp(lnU)\theta}{\exp\{\Pi(p,E)\exp(lnV)\theta} \qquad (4)$$

Where

π = predicted actual profit

Π^{max} =predicted maximum profit

Given the density function $U_i$and V_i the frontier, the profit function can be estimated by the maximum likelihood technique.

E (π) takes the value between 0 and 1. If U_i = 0 i.e. lying on the frontier, the farmer has potential maximum profit given the price it faces and level of fixed factors while if U_i > 0, the farm is inefficient and operates on lower profit because of inefficiency. Subsequently, Coelli (1996) and Ojo *et al.*, (2009), the stochastic frontier function with behavioural inefficiency components were used to estimate all parameters together in one step maximum likelihood estimation procedure.

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Therefore, the explicit Cobb-Douglass functional form of the Amaranth producers in the study area was specified explicitly as presented in equation (5).

$$\ln(Y_i) = ln\beta_0 + ln\beta_1\, ln\,(Z_{1i}) + \beta_2 \ln(P_{2i}) + \ln\beta_3(P_{2i}) + ln\beta_4(P_{3i}) + ln\beta_5\,(P_{4i}) + ln\beta_6(P_{5i} + \ln\beta_7\,(P_{2i}) + (V_i - U_{it}) \quad \ldots\ldots 5$$

Where

π = normalised profit function computed as the total revenue less variable cost per output price,

Z_i=farm size (ha),

P_i= Normalised price of labor (price (ZAR) per man-day of labor),

P_2= Normalised price of fertilizer (price (ZAR) per kg of fertilizer),

P_3= Normalised price of seed (price (ZAR) per kg of seed),

P_4=Normalised price of agrochemical [price (ZAR) per liter of agro-chemical],

P_5=Normalised price of irrigation water (cost of irrigation water (ZAR)/liter),

Z_2=Annual depreciation on farm tools,

β_0=Intercept/constant,

$\beta_1 - \beta_7$=Parameters to be estimated,

U_i=Non-negative (zero mean and constant variance) random variable called profit inefficiency effect associated with the profit efficiency of the ith farmers.

U_{ij} is the profit inefficiency effects which are assumed to be independent of Vij's such that Uijs is the nonnegative truncation (at zero) of the normal distribution with mean Ui and variance (δ2V). Where Ui is defined as shown in equation (6).

$$U_i = \delta_0 + \delta_1 G_1 + \delta_2 G_2 + \delta_3 G_3 + \delta_4 G_4 + \delta_5 G_6 + \delta_7 G_7 \ldots\ldots 6$$

Where,

U_i= profit inefficiency of the ith farmer, G1i = Age of the ith farmer (in years), G2i = Level of education of the ith farmer (number of years spent in school), G3i = Farming experience of the ith farmer (in years), G4i = household size of the ith farmer (number), G5i = Extension contact (number of meeting during production process), G6i = Gender (1 for male, 0 for female), G7i = Credit status of the ith farmer (1 for access to credit, 0 otherwise), G8i = Status of Membership

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of the cooperative society of the ith farmer (dummy variable, whereby, 1 for membership, 0 for otherwise).

δ1- δ7 =unknown parameters to be estimated. The parameters of the stochastic frontier profit function were estimated with the FRONTIER version.

4. RESULTS AND DISCUSSION

This section is divided into two section, first one being descriptive results which profile the farming system of cabbage farming while second section being empirical results**.**

4.1 Demographic characteristics of cabbage farmers

Demographic characteristics of farmers are indispensable when analysing the economic data because such factors influence the farmer or homesteads economic behavior. Demographic characteristics and socio-cultural contexts are important variables as they illustrate the key factors in the socio-economic analysis of smallholder systems. Table 3 below is illustrating the farmer's profile and characteristics in the study area.

TABLE 3: Socio-economic features of cabbage farmers.

Variable	Mean	Standard Deviation
Age	60.761	12.263
Years spent in school	5.650	4.406)
Household size	4.570	2.468
Farm Experience	11.295	10.546
Farm Size	3.456	1.026
Capital (Cost of the tractor used) (Rands)	500	72.53
Labour (man-days)	22	25.254
Seeds (Kg)	20.25	5.256
Fertilizer (Kg)	42.356	37.256
Gender: Male Female	69% 31%	

Member of Farm Organization		
Yes	70%	
No	30%	

Source: Field Survey, 2017

The findings indicated that most of the farm households were headed by men with a share of 69% compared to 31% females. These results are consistent with Kibirige *et al.*, (2016) that farming in the province is dominated by men as women are taking care of the family and household chores. The average age of the household head amongst smallholder farmers was 60 years, which implies that farming is dominated by elderly persons in the study area. Probably, this was necessitated by mass retrenchments at the mines in the wake of mechanisation of mining operations that began in 2010(Christian, 2017). Smallholder cabbage irrigators are mostly literate as most of the respondents have primary education, having spent approximately 5 years in school and household size averaged at 5 members. Household size was used a proxy for farm labour, so having high household size was beneficial in providing additional labour to the farm from family members. The farming experience was averaged at 11 years and this plays a big role in assisting farming in participating in markets to enhance farm returns. This indicates that experienced farmers were capable to adjust to innovative technological development and thereby, improve their cabbage production systems. The results indicated that 70% of the farmers were members of farm organisations since they are full-time farmers. This shows that farmers were able to get required training from farm organization with regard with farming. Labour is the most important input for cabbage production, especially, with smallholder farmers. The average amount of family labour used is estimated to be 22 man-days per farm. The average cost of a tractor was ranging from ZAR400.00 to ZAR850.00 per ha. In addition, the average farm size in the study area is 3 Ha. Smallholder farmers' average amount of seed used by a farmer per Ha is ZAR20.25 while those farmers who apply fertilizers use about 42.356 Kg.

4.2 Estimates of Stochastic Production Frontier of cabbage production

The estimates of the maximum likelihood ratios for the parameters in the single equation reduced form proposed in equation (3) above are presented in Table 4. Table 4 shows the estimated cabbage parameters results obtained from the Cobb-Douglas production function model and presents results concerning the extent of technical efficiency in the smallholder farming system.

The diagnostic statistics showed that the estimated sigma-squared (δ2) is significant at the 5% level. This indicated a good fit and the correctness of the specified distributional assumptions of the composite error term. In addition, the estimated lambda (Y) of 0.715, which is the ratio of the variance of farm-specific profit efficiency to the total variance of the profit was significant at the 1% level of significance as indicated in Table 4, indicating that 71.5% of the variation in actual profit from maximum profit (profit frontier) among cabbage farms was due mainly to differences in farmers' practices, one-sided error. Therefore, 1.1% was because of stochastic disturbance with two-sided error, supported by high t-value estimations of the highest likelihood share for the technical efficiencies of smallholder cabbage farmers as shown in Table 4. Table 4 displays the projected cabbage estimated outcomes found from the Cobb-Douglas gathering determination regression and contributions effects concerning the degree of practical capability in the emerging agriculture structure.

TABLE 4: Estimated Cobb-Douglas production function for cabbage enterprise

Independent Variables (in natural logarithm)		Cabbage Output (Y) = Dependent Variables		
	Parameter β	Coefficient	S. E	P > |z |
Land size under maize farming (Ha)	β_1	0.8543	0.178	0.000***
Fertilizer applied (Kg/ha	β_2	-0.8434	0.016	0.078
Capital (Tractor hours) Rand	β_3	0.096	0.258	0.016**
Seed planted (Kg/ha)	β_4	0.5686	0.0124	0.001***
Labour used (Hours)	β_5	-0.2354	0.045	0.018**
Constant	β_0	0.351	0.160	0.276
sigma_v		0.059	0.034	
sigma_u		0.7575	0.1229	
sigma2		0.5738**	0.1861	

Lambda		0.715***	0.787	
Log likelihood = -107.8467 Prob > chi2 = 0.0000 Wald chi2(4) = 16.522 Number of Observation (n=150) Average Technical Efficient = 0.7884				

Noted * and ** denotes importance equal at 1% and 5% correspondingly**

Source: Field Survey, 2017

In Table 4, it is clear that land ownership and use of tractors are important contributors to the gross income of smallholder farmers without bias to the total levels of incomes eventually achieved. The land was found to be significant at 1% and their coefficient was positive. This implies that a one unit increase in land ownership will provide extra hectares available for ploughing. Hence, cabbage productivity will increase farm profit by 0.8543 and consequently, the yield will increase, which results in profit maximation. The tractor was found to be significant at 5% and their coefficient is positive. This simply implies that an increase in tractor use will increase cabbage production because tractor use provides extra mechanical power, thus cabbage productivity increases, resulting in profit maximation of farmers by 0.096.

Further, the indication in Table 4 states that purchased inputs such as seeds and labour strongly influence gross income in the farming system studied. Labour was found to be significant at 5% and their coefficient is negative. This implies that a rise in labour use will result in a decrease in profits in cabbage production by 0.2354. This shows that an increase in the amount spent on this variable led to a decrease in the profit efficiency of the cabbage farmers. This suggests overuse of the labour to the point of diminishing returns. Seed planted by farmers was found to be significant at 1% and has a positive coefficient. This implies that an increase in the improved seedlings of cabbage use turns to increase the farm profitability, subsequently increasing cabbage technical efficiency by 0.5686. This paper made use of a tractor as a proxy to estimate capital used in the farm. The elasticity of capital was found to be 0.096. Capital was positively significant at a 5% level towards the production of cabbage.

However, from the point of view of technical efficiency, the lower panel statistic denoting the diagnostic statistics shows a log-likelihood ratio of 107.8467 and a lambda value of 0.015. The estimated stochastic frontier showed a significant Wald chi-square value of 16.522 overall sample and significant at 1% and 5%. The lower panel statistic denoting the value of Lambda which is the variation ratio (Insig2V and Insig2U) yields more policy-relevant information. Based on the relationship depicted in equation (3) above, it is clear that the estimates indicate high random errors with the high variance of the random component. Further, the "rho", calculated by the formula:

$$rho = \frac{(sigma\_U)2}{(sigmA\_U)2 + 1)} \quad \ldots\ldots(5)$$

The value of lambda, which is the variance ratio (sigma_u/ sigma_v) indicates that 0.001686 of disturbance in the system is due to inefficiency, one-sided error and therefore, 78.7% due to stochastic disturbance with two-sided error supported by a high t-value (Nwachukwu & Onyenweaku, 2019). The rho is almost close to zero, at 0.00577 (not different from zero). Given that the LR test tests the hypothesis that "rho" =0 (see Table 2 above) and "rho" gives the proportion of the total variance contributed by the variance components, it can be concluded that all the variance in the estimates come from the variables themselves and because of an error. This would suggest high degrees of inefficiencies in resource use in the smallholder system. Thus, while tractor use and land might contribute to gross income growth, there is clear evidence of not using resources inefficiently, which is consistent with generally-held views of farmers in the study area. There is evidence of underutilisation and poor planning that have characterised smallholder farmers' recent economic management processes. As a result, some effects have already been felt in the failing of the primary markets that assist smallholders' farmers with negative consequences for smallholder livelihoods and welfare.

Since the functional form of the model cannot be definitively predicted by graphic inspection, a multivariate Ordinary Least Squares (OLS) of technical efficiency scores against explanatory

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variables for smallholder maize producers. A relationship between the two was established, fitted and the results are presented in Table 5. This technique is mostly used in examining profitability and efficiency of vegetable production and previous studies such as Obi and Chisango (2011) and Kibirige and Obi (2015) made use of this technique. The present one attempted to investigate the effect of some factors (determinants) influencing the technical efficiency of farmers using the ordinary least square (OLS). The explanatory variables were specified as those related to socioeconomic, institutional, and farm factors of the smallholder farmers.

These two models serve different purposes that need to be explained. Table 4 presents results concerning technical efficiency while Table 5 presents insights into the determinants of technical inefficiency in the Eastern Cape smallholder sector under cabbage production of the type described in this paper. Additionally, Table 5 indicates that the model is more or less linear and that most of the gross income earned in the smallholder sector examined is explained by the model. Table 5 presents the results of the multivariate OLS, which are close enough to the frontier estimates to advise a general linear model. The model fit is acceptable, both in terms of the whole model and the individual regression coefficients. The R^2 value of 62%, which adjusted R^2 to 60%, suggests a good fit while the F-statistic of more than 56 confirms the whole model suitability. An average technical efficiency level of 78.1 percent, which implies approximately a 21.16 percent inefficiency level is observed in the study.

TABLE 5: Determinants of Profit Inefficiency among Cabbage Production

Variable	α_i	Coefficient	S. E	P-value
Farm experience	α_1	0.045	0.043	0.034**
Years in school	α_3	0.368	0.176	0.037**
Access to extension services	α_4	0.0133	0.0125	0.002***
Household size	α_5	0.0032	0.0105	0.014**
Access to credit	α_6	− 0.3655	0.3828	0.039**
Transportation to markets	α_7	-0.3655	0.1512	0.016***
Constant	α_0	0.037	0.004	0.016***

R^2 = 0.620 Adjusted R^2 = 0.600 F-Value = 56.53*** Prob > F=0.0000 Number of Observations (n = 150)

Note: Significance denoted as follows: ** (5%) and * (1%)**

Source: Field Survey, 2017

The explanatory variables were measured as those correlated to socio-economic factors of the smallholder irrigated cabbage farmers in the Eastern Cape irrigation schemes. For all the variables that have a positive coefficient, it implies that as each of them (while other variables held constant) is increased, cabbage output also increases leading to high farm returns. The positive coefficient estimates variables (farm experience, age, years in school, access to extension service and households' size) imply that there is a positive association among explanatory variables and reliant variables. Similarly, findings by Sapkota *et al.* (2017) and Illukpitiya (2005) reported similar findings in Nepal and Sri Lanka that aging farmers had a wealth of experience, therefore, they were more technically efficient in cabbage production than their younger counterparts. The results are in line with the findings of Sapkota *et al*. (2017) that farm experience increases technical efficiency because knowledgeable growers can accept the newfangled equipment for cabbage production and have a direct relation with extension personnel to inform cabbage farmers about innovative techniques and studies that will improve their cabbage productivity. These results were similar to Thabethe *et al*. (2014) that farm experiences assist in farm decision making and what is farm need in order to improve productivity. Likewise, a 1% increase in years spent in school will induce a 0.368% increase in cabbage output of the farm households. The results are in line with findings of Mutenheri *et al*. (2017); Supaporn (2015) and Thabethe et al. (2014) who found similar results in their studies that years spent in school increase the cabbage output of farmers, subsequently improve farm returns.

A positive coefficient of extension services implies that a 1% increase in extension services will induce a 0.013% increase in cabbage output. Extension services support farmers in bridging the gap between technology and formal education through field demonstrations and farm visits (Mapiye et al., 2021). Similarly, a 5% increase in household size will increase cabbage output of the farm households. This is the case as large household size was imperative through provision of farm labour as household size was used a proxy for farm labour. These results are in line with Kibirige et al. (2016) that increases in household size increase productivity as well as increasing concentration levels of farmers in demanding more farm tasks, which results in improving technical efficiency. However, the negative coefficient estimate for access to credit and transportation to market implies an inverse proportional relationship with technical efficiency (dependent variable). This simply means an increase to credit and transportation by farmers, will result to a decrease farm return of farmers. this suggests that lack of financial support to farmers' adversely affect cabbage production as farmers struggle to purchase inputs as they are constrained financially. These farmers are in remote or marginalized areas which adversely affect farmers in terms of reaching markets as transportation costs are very high for farmers. high transaction costs adversely affect farmers in accessing markets.

4.3 Efficiency indices of cabbage farmers

This section explains the efficiency indices of cabbage farmers found in the Eastern Cape Province. The average technical efficiency of emerging cabbage growers was 0.7884. Table 6 below is further showing the indices observed of cabbage farmers.

TABLE 6: Efficiency indices of cabbage farmers (n = 150)

Efficiency Indices	**Frequency**	**Percentage (%)**
0.01-0.09	10	8.0
0.10-0.19	15	10.5
0.20-0.29	18	15.00
0.30-0.39	12	10.6
0.40-0.49	16	11.4
0.50-0.59	08	2.8
0.60-079	44	20.6
0.80-095	15	10.5

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0.95-1.00	12	10.6
Total	150	100
Mean	0.7884	
Maximum	0.8002	
Minimum	0.0005	

Source: Field Survey, 2017

Table 6 illustrates the distribution of profit efficiency of smallholder cabbage farmers. The profit efficiency ranged between 0.0005 and 0.80021 for the worst and best-practice farmers respectively and with a mean profit efficiency in the study area of 0.7884. This implies that the average cabbage farmer in the study area could increase profit by 78.84% by improving his/her technical and allocative efficiencies. This means that there are prospects for the farmers to increase their farm incomes, thus reducing poverty and food insecurity. The wide variation in profit efficiency is in line with Adeleke, et al. (2008) who stated that a mean profit efficiency level of 0.422 (0.05- 0.99) for smallholder farmers in Atiba Local Government Area of Oyo State. The low level of profit efficiency observed was because of farmers who did not optimally allocate existing resources to force the achievement of frontier profits. Even the best-practice farmer requires a cost-saving to function optimally.

4.4 Challenges faced by cabbage farmers

Farmers in the Eastern Cape Province are faced with many challenges which vary from farmer to farmer depending on his or her location. Table 6 below is showing different challenges these cabbage farmers are facing.

TABLE 7: Challenges faced by cabbage farmers (n=150)

Challenges	**Percentages**
Lack of agrochemicals	88%
Lack of finance	82%
Lack of storage	68%

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High input costs	60%
Lack of market information	65%
Inadequate access to extension services	60%

Source: Field Survey, 2017

The majority of cabbage farmers lack agrochemicals due to the high costs associated with acquiring them. The second challenge is finance, which is not surprisingly so because most of the farmers depend on old age grant for living and do not have any other source of finance in assisting them in operating the farm. Lack of finance adverse effect farmers as they struggle to purchase inputs, they cannot build or hire storage for their perishable produce, forcing them in selling them straightaway after harvest. The lack of finance further affects the purchase of inputs as farmers do not have the necessary income to purchase them which is the most common thing in developing countries. Cabbage farmers also lack market information which is necessary for marketing their products and meet market standards. Lack of extension personnel also affects cabbage farming in the study area.

5. CONCLUSIONS AND IMPLICATIONS FOR POLICY

The study examined the smallholder farmers under irrigation schemes relating to cabbage production in the Eastern Cape Province. Production of cabbage by smallholder farmers plays a significant role in alleviating poverty, generating income and contributing to a balanced and healthy diet. Cabbage production in the study area is practised by men with an average age of 60 years and a mean household size of 4 persons with the household head having at least obtained some primary school education. The study indicates that farmers in the study largely depends on social securities (old age grant) and farming as their main activity and have vast farm experience of over 11 years. Cabbage production was found to be a profitable enterprise in the study area. Land ownership, seeds and tractor use were significant in explaining the profit efficiency of the farmers. The results show that the farmers are generally profit efficient but can improve on it by up to 78.84% indicating that there remains the substantial possibility to increase profits by improving the technical efficiency of smallholder farmers. The production function analysis revealed that inefficiency exists among cabbage farming households in the study area. The major

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problems encountered by smallholder cabbage farmers include a lack of agrochemicals, a lack of funds, a lack of storage, high input costs, a lack of market information and inadequate access to extension services. In conclusion, socio and institutional factors were technical inefficiencies. The study recommends the availability of fertilizer to smallholder vegetable farmers by both private and public (Department of Agriculture) sectors at an affordable rate. The government (National Department of Agriculture, Land reform and Rural Development) is urged to introduce subsidies to smallholder farmers as a way of increasing their financial availability to purchase inputs, pay labour and assist in operating the farm. Government should strengthen the strategy of on-farm training to smallholder irrigators and must embark on training extension workers about new technologies and techniques to improve agricultural productivity, marketing and dynamics of marketing to improve farm profitability and efficiency. Policymakers and NGOs must develop models which will attract youth and women to agriculture and be hands on in terms of production.

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7. CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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