Determinants of Agricultural Efficiency of Farmers on Small-scale Irrigation Schemes in the Eastern Cape Province of South Africa: A Case Study of Qamata and Tyefu Irrigation Schemes

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Abstract

Although revitalisation of small-scale irrigation schemes in rural South Africa is thought to be among the crucial development pathways for millions of people, most of the established small-scale irrigation schemes are reported to be underutilized and abandoned. Information regarding the performance of these irrigation schemes is constantly needed for designing policies that target increased food security and poverty eradication in rural South Africa. This paper established the technical, allocative and economic efficiency levels and determinants thereof of small-scale farmers nearby and at Qamata and Tyefu irrigation schemes in the Eastern Cape Province of South Africa. The paper employed the Data Envelopment Analysis (DEA) approach to estimate the technical, allocative and economic efficiency levels of farmers. At least 108 small-scale irrigators and 50 homestead food gardeners were interviewed as a source of primary data. The findings of this study indicated that small-scale irrigators were significantly (at 10% level) more technically and economically efficient (T.E = 0.620 and E.E = 0.434 scores) compared to homestead food gardeners (T.E = 0.564 and E.E = 0.383 scores). Generally, allocative efficiency results for both Small-scale irrigators (A.E = 0.694 scores) and homestead food gardeners (A.E = 0.670 scores) indicated an over-expenditure on variable agro-inputs. Determinants of small-scale irrigators’ maize production efficiency were related to human capital (Farming experience, education level, and access to training) and commercialization level of maize produced. Off farm incomes earned was the main determinant of homestead food gardeners’ maize production efficiency. Therefore, for meaningful revitalisation and performance of small-scale irrigation schemes in South Africa, formulation and implementation of participatory policies geared towards improved quality of human capital among small-scale irrigators, access to agribusiness training and increased access to agro-markets need to be addressed as a matter of urgency.

Keywords: DEA Approach; Technical efficiency; Allocative Efficiency; Economic Efficiency; small-scale irrigators; South Africa

1. Introduction

Irrigation farming is an old phenomenal whose first systematic application was recognised in the ancient Mesopotamian plains (Hill, 1984). The importance of irrigation technology has been recognised for a long time (UNWWD, 2012). Worldwide, research findings confirm that crop production under irrigation results in yields of about 2.7 times more than those of rain-fed farming (UNWWD, 2012). Research carried by Lipton et al. (2003) declared that the first direct impact of irrigation is on output levels. In South Africa on a private basis, irrigation farming started as early as 1652 at the arrival and settlement of Europeans. As the population of people and demand increased in South Africa, irrigation farming grew and became more organised (Perret and Touchain, 2002; Kodua-Agyekum, 2009). Notwithstanding the growth and organisation of irrigation schemes in South Africa, in 1930, the country suffered severe drought and economic depression (Van Averbeke et al., 2011). This led to designing and implementing economic growth programmes directed toward catalysing irrigation farming as a remedy for increased agricultural productivity, food security, and rural employment. Among others, the strategies included establishment and allocation of large commercial scale irrigated farms to White farmers, and Black farmers were allocated small-scale irrigation schemes mainly considered as food plots (Van Averbeke et al., 2011). Establishment of these irrigation schemes yielded positive results especially in terms of eradicating and mitigating hunger in the short run with a less meaningful contribution to black farmers’ household incomes, and rural poverty eradication (Kodua-Agyekum, 2009).

As South Africa moved towards the end of the apartheid era, the government lessened allocation of resources towards small-scale irrigation schemes (Kodua-Agyekum, 2009). This was worsened by the post-apartheid government pull-out of full-support and management of the state-established irrigation schemes, leading to
collapse of a big number of these schemes countrywide (Backeberg, 2005; Sishuta, 2005; Kodua-Agyekum, 2009; Van Averbeke et al., 2011; Kibirige, 2013). As a result, smallholder irrigation plots in rural areas of South Africa are not intensively utilized, and most of them are lying idle (Manona et al., 2010; Perret, 2004, Kibirige, 2013). Small-scale farmers’ contribution to mitigating hunger and reducing rural poverty is without challenges. Most small-scale irrigators on irrigation schemes formerly owned by the government are characterised by low formal education, aging, resource poor and lack access to services like training/extension services, markets and good public infrastructure with less accumulated external social capital (Backeberg 2005; Liebenberg and Pardey, 2010). South African small-scale irrigators’ pathetic situation has been worsened by deepening monetization of the agrarian economy which has led to the abandonment of some of their fields and resorted to intensifying cultivation of small garden plots adjacent to their homestead “homestead food gardens” (du Toit and Neves, 2007; Nondumiso, 2009). For example, poor small-scale irrigators can hardly meet additional input costs required to hire either a tractor or animal attraction to plough (du Toit and Neves, 2007). The young generation has concentrated on attending school without enough time to participate in farming activities. This has prevented the transfer of skills from parents to the young generation, referred to as “bovine deskilling” resulting in more abandonment of numbers of small-scale irrigation schemes plots (du Toit and Neves, 2007).

Although small-scale irrigation farming is inevitable, abandonment of irrigation schemes may relieve South African’s agricultural water consumption since the country suffers from limited water availability (Kibirige, 2013). According to Kibirige (2013), only 49 228million m³ per year of runoff water, mainly from rivers, is available for over 51.7 million people in South Africa. Thus, only 952m³ per year of water is available for use per person. Samuel (2009) indicated that, for a country to be declared “water stressed,” the annual water supplies drop below 1,700m³ per person, while Backeberg (2005) indicated a threshold of 1000m³ of water supply per person per year. Therefore, the per capita water availability of 952m³ per year is below the two thresholds, indicating that South Africa is a “water stressed” country (Backeberg, 2005). More efforts and commitments are being made by the current government to encourage more innovations geared towards increased smallholder productivity (Zuma, 2011). Revitalisation of irrigation scheme was among the strategies availed by the government although many farmers may be hesitant to shift from homestead food gardening to revitalised irrigation schemes (Hajdu et al., 2012). Given the current economic status of these farmers, homestead food plots would be their ideal option because they consider it as more efficient and intensive compared to the distant small-scale irrigated food plots which are less fertile and demanded more of the unavailable agro-inputs and human labour (Hajdu et al., 2012). This puzzle and indecisiveness faced by small-scale farmers to either shift back to irrigation scheme plots or maintain the status quo may equally frustrate governments.

For a concrete decision, one may need to establish the performance of both small-scale irrigation and homestead food gardening. Empirical studies indicate that farmers in developing countries are unsuccessful in taking full advantage of the potential of technology like irrigation schemes and other support for increased productivity (Kibirige, 2013). Therefore, this article was aimed at informing the government, and farmers on the performance of the two systems to ascertain the meaningful and appropriate development pathway that will catalyse the shift to a more productive and commercialised small-scale farming. One of the most widely used methods to assess the performance of farmers is through estimating their production efficiency. Padilla-Fernandez and Nuthall (2001) cited Farrell (1957) defining efficiency as the ability to produce a maximum level of output at the lowest cost. Efficiency can be divided into two concepts, the technical and allocative efficiency. Technical efficiency is the ability of the farm to produce a maximum level of output given a similar level of production inputs. Allocative efficiency literally can be defined as generating of output with the least cost of production to obtain maximum profits. For the farmer to achieve economic efficiency, they have to combine resources in the least combination to generate maximum output as well as ensuring least cost to obtain maximum revenue (Chukwuji et al., 2006). In cases where farmers’ efficiencies differ among the communities or groups, improved technological diffusion and agronomic practices are essential, and where all the population is found to be technically efficient, more innovation and adoption of new technologies can be encouraged.
2. Methodology
This study selected at least one small-scale irrigation scheme from Qamata and Tyefu, the former being located in the Transkei and the latter located in the Ciskei state, respectively, to ascertain the impact of the irrigation schemes on maize production efficiency and to identify the determinants of farmers’ maize production efficiency. With the aid of an extension worker’s and community development officer’s guidance, farmers were randomly selected and interviewed. A total of 102 farmers were interviewed in Qamata and 56 farmers at Tyefu irrigation scheme, respectively. This resulted in an overall sample size of 158 farmers. To generate more authenticable results, both, measurements and observation methods, and participatory approaches were employed. The data for the study were essentially from primary sources with the use of a well-structured questionnaire. The majority of the interviews occurred in the communal meeting places. The only exception was in the case of Tyefu small-scale irrigators who were interviewed at their irrigation food plots. The questionnaires were pre-tested on a sample of farmers in the study area. The questionnaires comprised farmer characteristics, agronomic practices, and crop production.

This article employed the Data Envelopment Analysis approach as used by Coelli (1996) Speelman et al. (2007) and Lembeta et al. (2012). Following Coelli (1996), Speelman et al. (2007) and Lembeta et al. (2012), the model presented in this article assumed that each of the N farms use K inputs to produce a given output M. For an individual i.th farm, input and output data are represented by the column vectors X_i and Y_i, respectively. The K x N input matrix or X_ij (where X_ij = Land acreage, number of irrigations/ha/season, amount of seeds planted, fertilizer, pesticide, herbicides, capital) and the M x N output matrix, or Y_ij (value of output of i.th farm &the the the the j.th crop enterprise) represent the data for all N farms in the sample.

In this article, the DEA model was estimated to generate production efficiency using linear programming equation following Speelman et al. (2007) and Lembeta et al. (2012) as presented below:

\[ \text{Min}_{\theta \lambda} \Theta \] 

Subject to:
\[ -Y_{ij} + Y \lambda \geq 0, \]
\[ \theta X_{ij} - X \lambda \geq 0, \]
\[ N1' \lambda = 1, \]
\[ \lambda \geq 0 \]

Where \( \theta \) is a scalar, N1 is a N x 1 vector of ones, and \( \lambda \) is an N x 1 vector of constants. The value of \( \theta \) obtained is the technical efficiency score for the i.th farm and these scores normally lie between zero and one. If \( \theta = 1 \) then the farm is said to be efficient and lies on the frontier, thus, the more \( \theta \) tends to zero the more less efficient the farm becomes. The (N1' \( \lambda \) = 1) is referred to as Variable Returns to Scale (VRS) with some specification as a convexity constraint. Without that constraint (N1' \( \lambda \) = 1), then efficiency estimates are calculated under Constant Returns to Scale specifications (CRS). Further, Färe et al. (1994) used the sub-vector efficiency to estimate the technical sub-vector efficiency for the variable input k like irrigation water for each i.th farm by solving the linear programme problem as shown below.

\[ \text{Min}_{\theta \lambda} \theta_k \] 

Subject to
\[ -Y_i + Y \lambda \geq 0, \]
\[ \theta_k X^k_i - X^k \lambda \geq 0, \]
\[ X_{i}^{n-k} - X^{n-k} \lambda \geq 0, \]
\[ N1' \lambda = 1, \]
\[ \lambda \geq 0, \]

Where \( \theta_k \) is the input k sub-vector technical efficiency scores for farm i. The second constraint with terms \( X^k_i \) and \( X^k \) includes only the K.th input and in the third constraint which contains terms \( X^{n-k}_i \) and \( X^{n-k} \) it excludes (thus, n - k) the K.th input. Other variables in this equation are defined in equation 1.

According to Coelli (1996), when estimating efficiency using the DEA model, there are two scale assumptions generally employed. Namely, the constant returns to scale (CRS), and variable returns to scale...
Farmers operate at different levels, and this can be demonstrated graphically based on whether or not observed levels along the frontier corresponding to a particular return to scale. The behaviour of the curves generated by the DEA approaches on the scale assumptions considered when modelling. The VRS consider both increased and decreased returns to scale while CRS assumes that output changes by the same proportion with a change in inputs employed. Further, VRS recognise variation in technologies (Coelli, 1996). Based on the assumptions that inputs are fixed and farms are producing optimally, figure 1 presents both the CRS and VRS frontiers. Assuming constant returns to scale, all farms operating below point C on the CRS frontier are considered inefficient and underutilizing resources. Assuming variable returns to scale, all farms operating below the VRS frontier defined by points A C D are considered inefficient. Thus, a farm operating at point B is considered inefficient.

![Figure 1: CRS and VRS Frontier](Source: Coelli (1996) cited by Kibirige (2013))

**3. Empirical Results**

**3.1 Demographic Characteristics of Smallholder Farmers in the Study Area**

Table 1 indicates that most farm households were headed by a male, the proportions significantly higher among the homestead food gardeners at a 5% level. Male’s dominance among both smallholder irrigators and homestead food gardeners (59% and 78% respectively) in the study area may be attributed to the loss of jobs through retrenchment policies and retirement. Further, over 90% farm plots on irrigation schemes and dry land were allocated to men due to the bias of African cultural rules and norms which deny women’s legal rights to own such a crucial agricultural resource (Kodua-Agyekum, 2009). According to the results presented in Table 1, there are relatively more women participating in irrigation farming (41%) than in homestead food gardening (22%). The increased number of women participating in irrigation farming may be due to affirmative action programmes and policies in recent years which promote women’s access and control over or inherit farm plots. Although there is an increase in women’s ownership of plots, that may not be the case for women participating in homestead food gardening where the traditional norms are still prevalent (Kodua-Agyekum, 2009).
Input Use among Smallholder Farmers

An independent sample T-test was carried out to establish the difference in input use between smallholder irrigators and homestead food gardeners. According to the results displayed in Table 2, there is a mean difference between average number of times of irrigation/ha/season of maize production, higher among smallholder irrigators (208.78 times/ha/season) and lower among homestead food gardeners (116.14 times/ha/season) at a 1% significant level. Smallholder irrigators devoted slightly less land (0.67ha) and

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The amount of fertilizer applied (58.03 Kg/ha), pesticide (0.74 L/ha) and herbicides (0.64 L/ha) per hectare used by smallholder irrigators were slightly more compared to homestead food gardeners who applied fertilizer of 50 Kg/ha, 0.73 L/ha of pesticide and 0.40 L/ha of herbicide, respectively. Thus, control of weed using chemicals and pest control using pesticides are mainly carried out by smallholder irrigators in maize production.

In South Africa, the recommended planting rates for improved maize seed generally range from 20 Kg/ha to 25 Kg/ha (Hassan et al., 2001). Therefore, the findings in this study indicate that both smallholder irrigators and homestead food gardeners planted maize using the recommended seed rate. The recommended fertiliser rates for irrigated maize vary depending on the yield potential but can be as high as 220 kg N ha-1 for a yield target of 10 t ha-1 in South African (Fanadzo et al., 2009). However, findings in this study indicate that smallholder irrigators and homestead food gardeners apply far less fertilizer than the recommended rate and these findings are consistent with Fanadzo et al. (2009) study whose results showed that on average, farmers applied only 47.6 kg N ha1 of fertilizers at Zanyokwe irrigation scheme.

### 3.3 Commercialization level of Maize Enterprises

Results presented in Table 3 reveal that smallholder irrigators generate significantly higher maize yield, more total revenues and higher gross margins from the maize enterprise at a 5%, 10%, and 1% levels, respectively as compared to the homestead food gardeners. Further, results indicate that smallholder irrigators produce a more marketable surplus of maize with a commercialization index score of 0.45 compared to 0.37 index score of the homestead food gardeners. However, homestead food gardeners spent more money on the purchase of inputs, and this may have contributed to their low gross margins. The low production costs incurred by smallholder irrigators may be due to their ability to benefit from government input subsidies. In South Africa, the potential grain yields that can be obtained under irrigation farming range from 7 to 12 tons/ha (Fanadzo et al., 2009). This indicates that maize yields for both smallholder irrigators and homestead food gardeners are far below the expected yields. This suggests that smallholder irrigators are sub-optimally utilizing irrigation schemes. The low yields may be attributed to low fertilizer, pesticides, and herbicides applications, among others. Further, the low use of these agro-chemicals may be due to lack of investment capital to purchase these inputs.

### Table 3: Profitability of Maize Enterprises among Smallholders

<table>
<thead>
<tr>
<th>Description</th>
<th>Smallholder Irrigators (n=108)</th>
<th>Homestead Gardeners (n=50)</th>
<th>Overall Sample (n=158)</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize yields Kg/ha</td>
<td>Mean (2199.59, 2967.64)</td>
<td>Mean (1468.497, 1488.9)</td>
<td>Mean (1834.04, 2228.27)</td>
<td>2.061**</td>
</tr>
<tr>
<td>Total revenues from Maize Rand/ha</td>
<td>(3469.89, 6560.57)</td>
<td>(241.48, 2900.1)</td>
<td>(2805.69, 4730.34)</td>
<td>1.765*</td>
</tr>
<tr>
<td>Total Cost for maize production Rand/ha</td>
<td>(1448.68, 2280.22)</td>
<td>(1869.30, 2803.02)</td>
<td>(1658.99, 2541.62)</td>
<td>-0.995</td>
</tr>
<tr>
<td>Gross margins from maize Rand/ha</td>
<td>(2021.209, 6035.331)</td>
<td>(254.655, 3012.671)</td>
<td>(1137.932, 4524.00)</td>
<td>2.444**</td>
</tr>
<tr>
<td>Commercialization Index (CI)</td>
<td>Ratio 0.45(0.37, 0.370(35)</td>
<td>0.370(35)</td>
<td>0.41(0.36)</td>
<td>1.324</td>
</tr>
</tbody>
</table>

Where *, and ** represents significance levels at 10%, and 5% level, respectively. (SD) = standard deviation. , ha = hectares. CI = Quantity marketed/ total quantity harvested.

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3.4.1 Estimating Production Efficiency in Maize Enterprise by the DEA Approach

The DEA model was run to estimate the technical, allocative and economic efficiencies of smallholder farmers in the study area as presented in Table 4. Considering the Variable Return to Scale (VRS) scores, both smallholder irrigators, and homestead food gardeners are technically efficient in maize production, although homestead food gardeners are more and significantly efficient at 10% level. Looking at the VRS index scores for both categories of farmers, smallholder irrigators had an average score of 0.983 while homestead food gardeners scored 0.996. However, the Scale Efficiency (SE) and the Constant Returns to Scale (CRS) index indicate that smallholder irrigators are slightly more technically efficient than homestead food gardeners.

Table 4: Estimating Farmers’ Maize Production Efficiency: DEA Approach

<table>
<thead>
<tr>
<th>Efficiency Categories</th>
<th>Smallholder Irrigators (n=108)</th>
<th>Homestead Food Gardeners (n=50)</th>
<th>Overall Sample (n=158)</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRS technical efficiency</td>
<td>0.98 (0.07)</td>
<td>1.00 (0.03)</td>
<td>0.99 (0.05)</td>
<td>-1.687*</td>
</tr>
<tr>
<td>Scale technical efficiency</td>
<td>0.72 (0.17)</td>
<td>0.68 (0.21)</td>
<td>0.70 (0.19)</td>
<td>1.375</td>
</tr>
<tr>
<td>CRS technical efficiency</td>
<td>0.71 (0.17)</td>
<td>0.67 (0.21)</td>
<td>0.69 (0.19)</td>
<td>1.049</td>
</tr>
<tr>
<td>Allocative efficiency</td>
<td>0.69 (0.13)</td>
<td>0.67 (0.13)</td>
<td>0.68 (0.13)</td>
<td>1.156</td>
</tr>
<tr>
<td>Technical efficiency</td>
<td>0.62 (0.17)</td>
<td>0.56 (0.22)</td>
<td>0.59 (0.19)</td>
<td>1.749*</td>
</tr>
<tr>
<td>Economic efficiency</td>
<td>0.43 (0.15)</td>
<td>0.38 (0.19)</td>
<td>0.41 (0.17)</td>
<td>1.876*</td>
</tr>
</tbody>
</table>

*Generated from DEAP (Version 2.1). Where ***, ** and * represents significance level at 1%, 5% and 10% level (Std Errors) = Standard errors; VRS = Variable Returns to Scale, CRS = Constant returns to scale.

Based on Table 4 results, the allocative, technical and economic efficiency index scores were generated using seed, fertilizer, pesticide and herbicide inputs because their prices and quantities were relatively more established and were used by both smallholder irrigators and homestead food gardeners in maize production. Results indicate that smallholder irrigators are more technically and economically efficient than homestead food gardeners at 10% significant level. In addition, the smallholder irrigators are slightly more allocatively efficient compared to homestead food gardeners in the use of seed, fertilizer, pesticide, and herbicide for maize production. According to the allocative, technical and economic efficiency, smallholder irrigators scored 0.694, 0.62 and 0.434 while homestead food gardeners scored 0.670, 0.564 and 0.383, respectively. Therefore, for maximisation of maize output and profits, smallholder irrigators need to improve on their economic efficiency by 56.6% while homestead food gardeners need to improve by 61.7% without changing the existing technology. As expected, smallholder irrigators are more technically and allocatively efficient because they have access to cheaper inputs, water for irrigation and use modernized irrigation systems compared to homestead food gardeners whose farming greatly depends on rainfall and mainly use inefficient traditional irrigation methods like buckets. The finding match with Kelemework (2007) who found out that farmers irrigating their fields in Batu Degaga area were technically more technically efficient at 76% compared with those farming on dry-land who scored technical efficiency of 66%. Theoretically, the adoption of new technologies is thought to increase efficiency and productivity among farmers (CIMMYT, 1993).

3.4.2 Determinants of Technical, Allocative and Economic Efficiency among Small-scale Farmers in Selected Study Area

An OLS linear regression model analysis technique was used to establish the relationship between the technical, allocative and economic efficiency scores as dependent variables against explanatory variables (farmer/farm characteristics) of smallholder maize producers at Qamata and Tyefu irrigation schemes. According to results presented in Table 5, the Durbin-Watson statistic for the overall regression models for T.E, A.E, and E.E were 2.027, 2.333, and 2.367 respectively, for small-scale irrigators signifying acceptable levels of autocorrelation. The F-values for the same multiple regression models of small-scale irrigators indicates that the explanatory variables combined, significantly influence changes in the T.E, A.E and E.E all at a 1% level, respectively. Generally, all the F-values for T.E, A.E, and E.E of homestead food garden indicated a significant relationship between the dependent and explanatory variables though at different levels of 1%, 10%, and 5%, respectively. These regression models of homestead food gardeners further
indicated that they were within the acceptable levels of autocorrelation since their Durbin Watson scores were above one.

Determinants of Small-scale irrigators’ technical efficiency include the age, education level and farm experience of the household head, access to training on input use, commercialization Level of Maize produced (Output sold/total output produced) and off-Farm Income (SA-Rand). Farming experience, access to input use training and commercialization level of maize farming among small-scale irrigators all indicated a significant and positive relationship with technical efficiency at 10% level while age and education level of the farmer also had a positive and significant impact on technical efficiency though at 1% and 5% level, respectively. Small-scale irrigators engaged in off-farm activities are more likely to be technically inefficient since off-farm income earned small-scale irrigators negatively and significantly impact on their technical efficiency in maize production. These results emphasise the importance of human capital (farming experience, skills, and formal education level) as a key factor in adopting technologies which in turn improves on technical efficiency. Since commercialization level of maize produced positively and significantly impact on technical efficiency, this is an indication that availability of agro-markets can stimulate improved productivity.

Table 5: The Determinants of Technical, Allocative, and Economic Efficiencies of Small-scale Farmers

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Dependent Variables Including TE, AE, &amp; EE of small-scale irrigators and Homestead Food Gardeners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small-Scale Irrigators</td>
</tr>
<tr>
<td></td>
<td>T.E</td>
</tr>
<tr>
<td>Age of Household Head (Years)</td>
<td>0.004***</td>
</tr>
<tr>
<td>(Years)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>Education level Household Head (years)</td>
<td>0.010**</td>
</tr>
<tr>
<td>(Years)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Farm Experience Household Head (years)</td>
<td>0.002*</td>
</tr>
<tr>
<td>(Years)</td>
<td>(0.001)</td>
</tr>
<tr>
<td>Size of land owned (hectares)</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
</tr>
<tr>
<td>Received training on Input Use (Yes/No)</td>
<td>0.057*</td>
</tr>
<tr>
<td></td>
<td>(0.034)</td>
</tr>
<tr>
<td>Farm Income (SA-Rand)</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
</tr>
<tr>
<td>Off-Farm Income (SA-Rand)</td>
<td>-0.000***</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
</tr>
<tr>
<td>Gross Margin of Maize (SA-Rand)</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
</tr>
<tr>
<td>Commercialization Level of Maize produced (Ratio)</td>
<td>0.79*</td>
</tr>
<tr>
<td></td>
<td>(0.045)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.186</td>
</tr>
<tr>
<td></td>
<td>(0.143)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.288</td>
</tr>
<tr>
<td>Durbin Watson Value</td>
<td>2.027</td>
</tr>
<tr>
<td>F-Value</td>
<td>4.308***</td>
</tr>
</tbody>
</table>

The standard errors are given in the parenthesis.

* = Significant at 10% level, ** = Significant at 5% level, *** = Significant at 1% level.


Source: Field Survey Data Generated using SPSS 2020 version.

Small-scale irrigators with larger plots are more likely to be allocatively inefficient in use the seed, fertilizers, pesticides, and herbicides; because findings of this study indicate that a unit increase in the land size owned by 0.029 units will result in a 5% decrease in allocative efficiency level. Land owned by the farmer was found to have a negative and significant impact on the allocative efficiency of small-scale irrigators’ maize production. However, if these farmers improve on access to training on input use by 0.047 units, and their gross margins on maize increase slightly then they are a more likely to improve on their allocative efficiency significantly at 10% and 1% level, respectively. Small-scale irrigators who are aged, more highly educated, well trained on input use, earning more gross margins from maize sells and are less engaged in off-farm employment are more likely to be economically efficient in maize production. This is because age and education level of the farmer and access to training on input use had a positive and significant impact while off-farm income had a negative and significant impact on the economic efficiency of small-scale irrigators’ maize production.
For homestead food gardeners, results presented in Table 5 suggest that off-farm incomes earned and commercialization level have a positive and significant influence on technical efficiency at 10% and 1% level, respectively. This may be attributed to farmers’ investment of off-farm incomes in purchasing agro-inputs to prove on productivity and an increase in their marketable surplus, and this attracts improved efficiency. Homestead food gardeners with larger plots are more likely to be technically inefficient since the size of land owned was found to have a negative and significant impact on the technical efficiency of maize production. This may imply that the farmers can hardly manage and maintain larger plots which demand more agro-inputs like fertilizers, seeds, pesticide, and herbicides simply because they are poor. Surprisingly, increasing marketable surplus (commercialization level) has a negative and significant impact on allocative efficiency at 1% level yet increased sales of maize is thought to bring in more incomes for purchasing more inputs in bulk and reduce on transaction costs. However, gross margins generated from maize sales had a positive and significant impact on the allocative efficiency of homestead food gardeners. Increase in size of land owned by homestead food gardeners has a negative and significant impact on economic efficiency at 1% level while the off-farm income of these farmers was found to have a positive and significant impact on economic efficiency at 10%.

4 Conclusion

According to the findings of this study, most farmers were men with an average age of 61 years, and mean household size of 4 persons with the household head having at least obtained some primary school education. Although smallholder irrigators generate more gross margins from maize enterprises, generally both categories of farmers (homestead food gardeners and small-scale irrigation farmers) exhibited a low average household commercialization index for maize of 0.41 scores. The poor utilisation of agro-inputs and irrigation water may be condemned for the poor yields of maize compared to the conventional expected yields. Although small-scale irrigators were significantly more technically and economically efficient in utilization of seeds, fertilizers, pesticides and herbicides compared to homestead food gardeners, both scores were considered to be low. Determinants of production efficiency of small-scale irrigators included the age of the farmer, education level, farming experience, access to training on input use and the commercialisation level of maize produced. The key determinant of production efficiency for homestead food gardeners was off-farm incomes. Therefore this study indicates the importance of improving human capital on irrigation schemes, training on agribusiness management and improving access to maize market for small-scale farmers, without changing the existing technologies.

5 Recommendations

For a successful agrarian reforms in South Africa which target revitalisation of small-scale irrigation schemes for increased productivity and survival of smallholder agriculture, there is need to put much more attention on factors related to attracting youth participation in agriculture production; promoting more food crop production; farmers’ improved access to input-markets; improved training on use of agro-inputs and improved quality of human capital among small-scale irrigators. More elaboration of these factors is presented as follows:

The results of this study suggest that most farmers are aged (> 60 years), implying that this farming generation is most probably less energetic and less enthusiastic and this may compromise the future rural-household food security in South Africa. For sustainable rural food security and general livelihood, the government and development partners need to develop agricultural programmes that encourage the creation of more associations or youth clubs engaged in farming. These programmes should incorporate agribusiness training, provision of financial assistance to avail start-up capital and enhance the youth economic empowerment. Despite the low gross margins and commercialization level of maize enterprise among homestead food gardeners and small-scale irrigators, there should be the emphasis on growing the crop. Since maize is considered the main staple food in South Africa, improved technical, allocative and economic efficient food production can be enhanced through policies that improve access to more resources like land, revitalisation of irrigation schemes and related financial programme for the crop. In addition to improved production efficiency of maize, research and development are also essential in innovating improved maize breeds that are resistant to diseases and tolerant to adverse climate change. This will safeguard rural households from high risks of food insecurity, under-nutrition, and the undesired livelihoods.
Allocative efficiency results in this study suggest that farmers need to search for cheaper maize seeds, fertilizers, pesticides, and herbicides in order to maximize profits. In order to access cheaper agro-inputs, efforts need to be made in terms of policy formulation and programs that attract agro-input dealers and agro-input industries to establish their businesses in rural areas. Among other strategies, including the establishment of agro-input dealers and small-scale farmers’ linkages through organizing workshops, use of media, and through farmer-public-private partnerships. In addition, improved allocative efficiency requires the provision of more farmer training in the efficient use of inputs and skills in farm business management. Low literacy levels, inconsistent farming experience, low access to training on use and application of agro-inputs are some of the factors reflected in the results that compromise the quality of human capital’s contribution to improved technical and economic efficiency on small-scale irrigation schemes. This implies that the withdrawal of South African government managerial, agro-input subsidies tractor-operation subsidies from small-scale irrigation schemes without a systematic and comprehensive training of farmers was untimely leading to poor performance and abandonment of these schemes. Therefore, the government should formulate and implement policies that are geared towards increased training of farmers on agronomic practices, increased access to agro-finance assistance and avail tractor subsidies in order to attract small-scale irrigators back to irrigation schemes from the subsistence homestead food gardens. Improved human capital is inevitable for the more efficient functioning of small-scale irrigation schemes that are in the process of being revitalised.

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