

## The Impact of Smallholder Irrigation Scheme on Household Welfare in Farm-Managed Irrigation Scheme Communities in the Eastern Cape Province, South Africa

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### **ABSTRACT**

*The smallholder irrigation scheme development is seen as an important strategy to transform resource-poor communities by enhancing food security and alleviating rural poverty, which has led the South African government to prioritise and invest significantly in irrigation establishment, rehabilitation, and revitalisation. However, little information is available on the effectiveness and impact of smallholder irrigation schemes in improving rural livelihoods. Therefore, the study aims to investigate the impact of smallholder irrigation schemes on household welfare, specifically on household income in farmer-managed irrigation scheme communities in the Eastern Cape Province, South Africa. Primary data in the form of structured questionnaires was used to collect data from 160 farmers using multi-stage sampling. Descriptive statistics and propensity score matching were used for analysis. The study results reveal that smallholder irrigation schemes can significantly transform smallholder farmers' lives by increasing productivity and providing reliable income from farming. The study found a positive impact and relationship between smallholder irrigation schemes and household welfare in the study. Farm characteristics and socioeconomic and institutional factors influence smallholder participation in smallholder irrigation farming. Based on the results, the study recommends that the government continue investing in irrigation schemes to increase the rural economy, improve rural livelihoods, and attract young people to farming. Department of Rural Development and Agrarian Reform must*

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*encourage farmer participation in irrigation schemes and build their capacity through training using agricultural extension agents and subsidising farmers with agronomic practices to improve participation in smallholder irrigation schemes.*

**Keywords:** Eastern Cape province, Household welfare, Irrigation schemes, Rural livelihood, Smallholder farmers

## 1. INTRODUCTION

There is a perception that irrigation is a first step in promoting development in impoverished rural areas. In South Africa, like in many other countries, smallholder irrigation farming has a long tradition; farmers use rivers and streams to irrigate small plots for grain crops and vegetables for home consumption (Ntsonto, 2005). According to Sinyola *et al.* (2014), smallholder irrigation schemes remain the key strategy to ensuring poverty reduction and household food security. Several studies have been conducted on the impact of household welfare after adopting the new technology, including irrigation schemes (Gebrehiwot *et al.*, 2018). Additionally, according to Adetoro *et al.* (2022), few studies have looked at the effect of irrigation farming on poverty vulnerability and the welfare of rural farming households. Moreover, few South African studies have established a positive association between participation in smallholder irrigation schemes, farming, improving livelihoods, and decreasing poverty (Moyo, 2016).

Smallholder irrigation schemes were developed in former homeland areas of South Africa during the apartheid era, primarily for community food supply purposes (Perret, 2002). Similarly, a study conducted by Hussain and Hanjra (2004) points out that agricultural water/irrigation has been regarded as an influential factor in providing food security, protection against adverse drought conditions, increased prospects for employment and stable income. Poverty reduction and household welfare are vital in developing countries, particularly South Africa (Sinyolo *et al.*, 2014). Smallholder irrigation schemes are important in improving rural livelihood for the poor and determining opportunities for reducing poverty (Moyo, 2016). This means that access to any irrigation water system allows farmers to increase their yield, improve household income, and diversify income opportunities.

The poor performance of the existing irrigation schemes means that the objective to improve food security and welfare in rural livelihoods through irrigated agriculture is not met. While the international experience shows that irrigation schemes are potentially transformative for poor

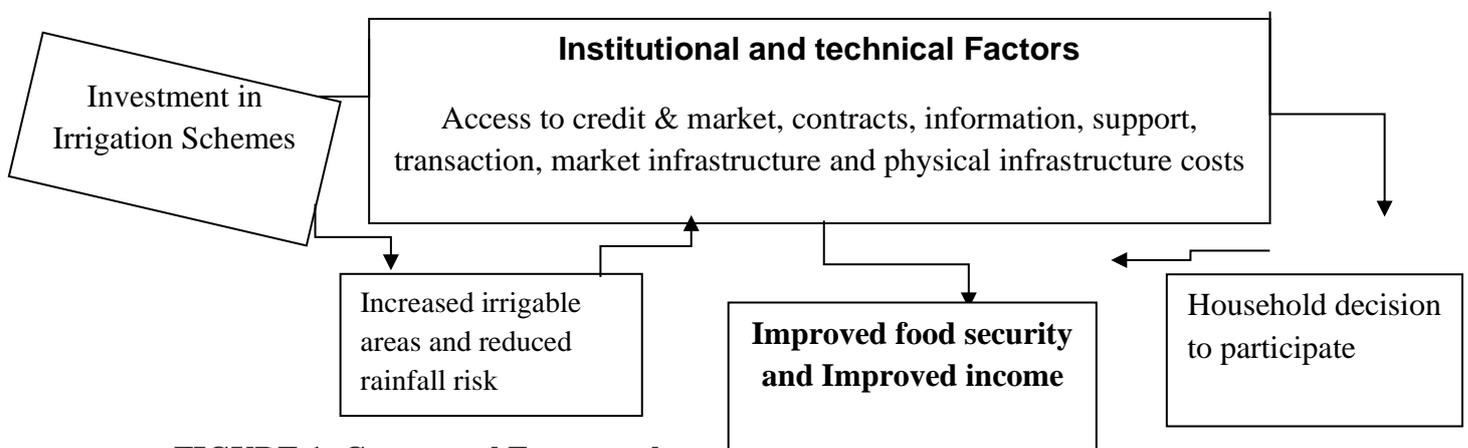
communities and have been operational for many years now, there is no marked improvement in living conditions of rural households in terms of livelihoods and income. In addition, limited access to resources greatly impacts low production; hence, they are still living under the poverty line. Moreover, although irrigation is perceived as a method of boosting agricultural production, many smallholder irrigation schemes in South Africa are performing poorly. Namara *et al.* (2010) added that access to good irrigation allows poor people to increase their production and income and enhances opportunities to diversify their income base, reducing vulnerability caused by the seasonality of the agricultural output as well as external shocks. Thus, access to good irrigation can contribute to poverty reduction and the movement of people from ill-being to well-being.

This study examined the factors that influence farmers' participation in irrigation farming and how they affect farmers' food consumption expenditure per capita (a proxy for welfare), poverty gap index, poverty severity, and vulnerability. Therefore, it will also provide evidence to inform policy measures to consider the importance of smallholder irrigation schemes.

## 2. LITERATURE REVIEW

### 2.1. Conceptual Frameworks

According to Nnenna (2011), small-scale farmers in rural areas lack basic infrastructure such as telephones, electricity, and good road networks. Small-scale farmers rely on poorly developed road networks and telecommunications (Ortmann, 2005). Most small-scale farmers cannot read, write, or speak any other language except their home language. This can create some difficulties when small-scale farmers must communicate with extension officers (Nnenna, 2011); lastly, the infrastructure for small-scale farmers of South Africa is poor, especially in former homelands of rural areas (See Figure 1).



**FIGURE 1: Conceptual Framework**

## **2.2. Opportunities and Future Development for Smallholder Irrigation Scheme's**

According to Machete *et al.* (2004), projects have been regarded as the most appropriate tools for promoting rural development in developing countries. According to Ndlovu (2013), due to the many individuals directly involved in agriculture and its production connections, agriculture stands out as the activity with the greatest potential to enhance rural incomes.

The project approach to development has been embraced in many developing countries, including South Africa (Moyo, 2016). Smallholder irrigation projects were established in the former homelands to promote food self-sufficiency and to contribute to rural development. In addition, Moyo (2016) further states that to create employment opportunities, it was hoped that smallholder farmers would improve their productivity and, thus, produce not only for home consumption but also for the market.

## **2.3. Improving Smallholder Irrigation**

The important constraints in contemporary smallholder irrigation identified by Bembridge (2000) and Crosby *et al.* (2000) were presented earlier. Rehabilitating the irrigation infrastructure, providing effective extension services, and facilitating access to information are public interventions that will undoubtedly benefit smallholders. They will not be discussed any further. Instead, the focus will be on selected opportunities for improvement that have received less attention.

## **2.4. Access to Markets**

In most rural areas, lack of market access has resulted from other factors such as poor road infrastructure, lack of communication between buyers and sellers, the inability of buyers to market or advertise their products and so on. According to Magesa *et al.* (2014), the aforementioned factor of poor road infrastructure tends to be very common and is also a factor that the farmer cannot solve.

## **2.5. Access to Credit**

Credit is one of the most essential and significant bases of capital generation and may be viewed as a device for facilitating the temporary transfer of buying power from one individual or organisation to another. According to Kimemia (2004), credit is also well presented as a key factor

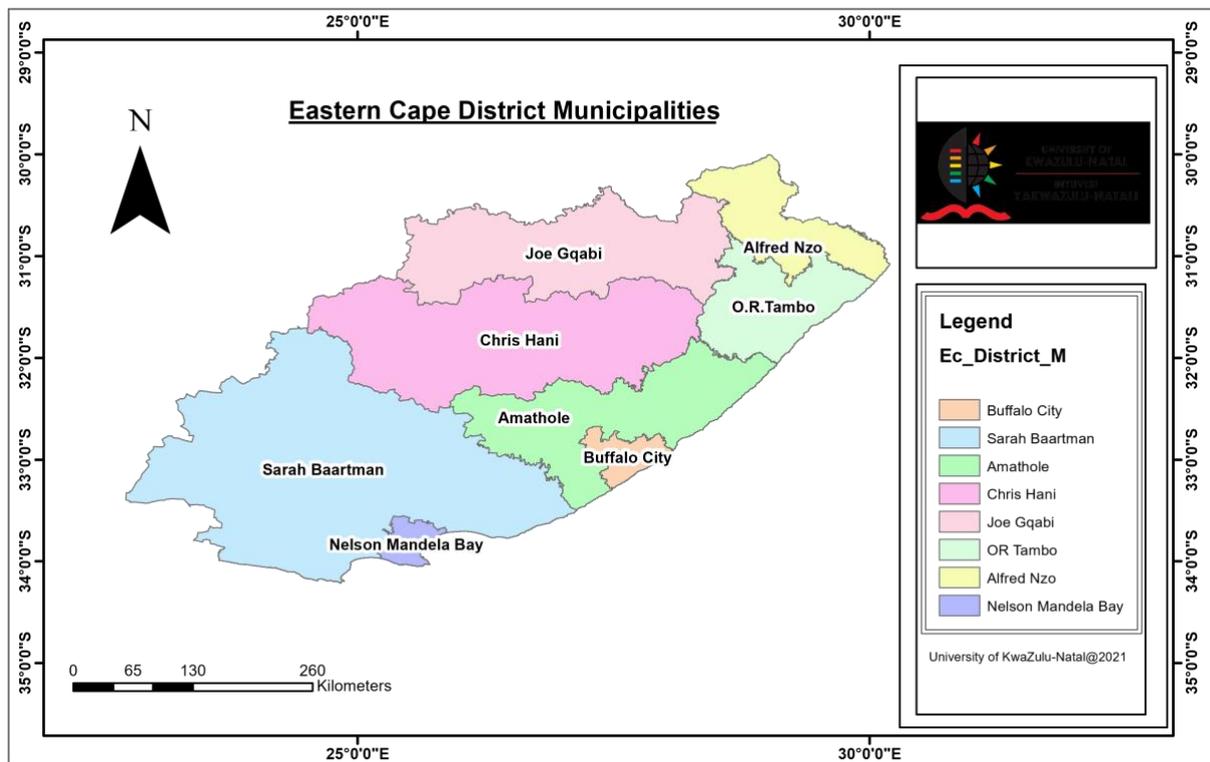
that can affect farmers' decision to purchase inorganic fertilisers, where farmers can afford the high prices imposed on fertilisers for their production.

### **3. METHODOLOGY**

#### **3.1. Study Area**

This study was conducted in the Eastern Cape (EC), which comprises Ciskei and Transkei's former homelands. Eastern Cape Province (ECP) is the second-largest province in South Africa regarding land size after Northern Cape, covering 13.9% of South Africa's area. Also, it is considered one of the second poorest provinces in South Africa (Statistics South Africa, 2015; OR-IDP, 2016). It consists of six district municipalities, namely, O.R Tambo, Chris Hani, Amathole, Alfred Nzo, Cacadu, and Ukhahlamba, with two metropolitan areas, including Nelson Mandela Bay and Buffalo City (OR-IDP, 2016). According to Statistics South Africa (Stats SA, 2017), the Eastern Cape has the third-largest population, with an estimated population of approximately 6 829 958, with most of the provincial population speaking the isiXhosa language. According to South Africa Eastern Cape Development Corporation [ECDC] (2018) and Statistics South Africa (Stats SA, 2017), most people in the province largely depend on the land, its natural resources, and agricultural livelihood strategies, including the production of potatoes to supplement their household needs. This trend does not seem to change (Naicker, Mathee & Teare, 2015).

The study was conducted in the Chris Hani and Amatole district municipalities in the Eastern Cape Province of South Africa. Two local municipalities were selected based on their agricultural activities: Intsika Yethu and Ngqushwa, which are situated in the former homelands Transkei and Ciskei, respectively. These local municipalities are home to Qamata (Tsomo, Qamata, and Cofimvaba) and Tyhefu irrigation schemes (serving Ndlambe, Pikoli, Ndwayana, Kaliken and Glenmore), which are contributing immensely to rural households' livelihoods in the Eastern Cape. These irrigation schemes were considered because they are among the largest smallholder irrigation schemes involved in crop and vegetable production and are still operational in these selected local municipalities. The study selected these two irrigations as they are situated in different district municipalities in the province, giving them different ecological climates and characteristics suitable for spinach production. Additionally, it was due to their repositioning of the popularity and size of the two schemes in the province. The study used a cross-sectional research design since the data was collected at a point in time.



**FIGURE 2: Map of Eastern Cape Province**

### 3.2. Sampling Procedure, Frame and Sample Size

The study applied a multi-stage sampling procedure to select sample respondents. First, Thyefu and Qamata Irrigation Schemes were selected purposively because of their potential in farming and because they were the most active irrigation systems in the province. These two irrigation systems were chosen randomly from the various irrigation systems because of their potential to contribute to the livelihoods of farmers who are members of the irrigation and non-members of the irrigation schemes. Following this, farmers were stratified into irrigation users and non-users categories. Lastly, the desired sample size was selected randomly for this study. The unit of analysis for this study was smallholder crop farmers who are members of irrigation schemes and non-users of irrigation schemes. The study sample size was 160 smallholder farmers, where 100 farmers were selected from the Thyefu and Qamata irrigation schemes, respectively, and 60 were non-users of the irrigation schemes.

The Cochran formula was used to calculate the sample size. Cochran formula was used to determine the sample size considering 95% confidence level ( $z=1.96$ ), 45% estimated proportion of an attribute in the population ( $p$ ) and 7% level of precision ( $E$ ) from 1084 total smallholder

farmers (Cochran, 1997). Thirdly, 100 irrigation users and 94 non-user farmers were selected randomly based on probability proportion to sample size:

$$\begin{aligned}n_0 &= \frac{(Z_{\alpha/2})^2 pq}{E} \\ &= \frac{(1.92)^2 (0.45)(0.55)}{(0.07)^2} \\ &= 194\end{aligned}$$

where  $n_0$  is the sample size,  $z$  is the selected critical value of the desired confidence level,  $p$  is the degree of variability in the population,  $q=1-p$ , and  $E$  is the desired level of precision. In social science surveys, a commonly used margin of error is 10% of the expected average value. In determining sample size, 3%, 5%, 7%, and 10% margin of error are accepted (Glenn, 1992). Kotrlík and Higgins (2001) argue that a 5% margin of error is acceptable in determining sample size. Others further argue that an acceptable margin of error survey researchers use falls between 4% and 8% at the 95% confidence level. However, for this study, considering available resources to manage the study, we used a 7% precision level to determine the sample size. Due to unforeseen challenges during the data collection, the study got 160 participating and non-participating smallholder farmers. The study's sample size was 160 smallholder and non-participating smallholder farmers.

### 3.3. Data Collection

The study used primary and secondary data, where primary data was collected from crop farmers between January 2018 and August 2019 using pre-tested structured questionnaires administered by trained enumerators. The questionnaire was prepared in a way that measured the objective of the study. To collect primary data from the respondents, researchers developed structured questionnaires focusing on demographic and institutional characteristics, the performance of irrigation schemes, the impact of participating in irrigation schemes on household welfare, and the farmers' challenges. The questionnaire was pre-tested in Mavusi in Alice before it was finalised. Pre-testing was conducted to improve the questionnaire and check on essential aspects such as the time to complete the questionnaire and the suitability and appropriateness of the questions. The pre-testing also afforded the research team time to train the enumerators on the questionnaire and general data collection mechanisms. After the training, the actual data collection was undertaken by those enumerators under the authors' supervision to solve any problems that occurred during

the data collection process. This study collected secondary data from different sources such as Department of Agriculture reports, books, journal articles, scholars, and farm records.

### **3.4. Data Analysis**

Data was coded in Excel and then transported to STATA 16 for analysis. Data were analysed using both descriptive and econometrics techniques. Descriptive statistics and Propensity score matching were used for analysis. Descriptive statistics was used as a preliminary investigation procedure to understand the significant socioeconomic characteristics of smallholder farmers participating in irrigation schemes and those not participating. This was done using means, bar and pie charts, frequencies and percentages. The impact of the smallholder irrigation scheme on welfare was estimated using Propensity Score Matching (PSM). PSM allows researchers first to estimate contributing factors to participating in smallholder irrigation schemes using probit regression and step two to assess the impact of smallholder irrigation scheme performance on household welfare (e.g household income) using PSM as it estimates the before and after effect.

#### *3.4.1. Probit Model*

The study used probit regression to estimate factors influencing the participation of smallholder irrigation schemes. The Probit model represents another widely used statistical model for studying data with binomial distributions. This model was selected since the dependent variable is binary and takes a value of 0 or 1. Furthermore, the Probit model is suitable for estimating parameters of interest when the dependent variable is not fully observed (Esabu & Ngwenya, 2019; Gichangi et al., 2019). The Probit model constrains the probability to a 0, 1 interval and assumes that an event will occur is non-linear and that the random error terms follow a normal distribution. i.e. Y will represent whether or not participating in the irrigation scheme yields positive or negative performance to smallholder farmers.

In the Probit model, the categorical (usually dichotomous) dependent variable was modelled as a linear (or log-linear) function of a combination of explanatory variables (Kabasiita et al., 2021). The Probit model accepts that while we only detect the values of 0 and 1 for the variable Y, there is a dormant, unseen, unceasing variable  $Y^*$  that determines the value of Y. The probit model was preferred over the logit model because it includes credible error term distribution and truthful probabilities (Nagler, 1994). The Probit model is detailed: Let us suppose  $Y_i$  is a binary response variable with only two possible outcomes. The model is based on the probability of success of an

event, which, in this case, is the good participation of smallholder farmers in irrigation schemes and their contribution to enhancing household income. The probability that an individual farmer will participate and perform well in an irrigation scheme depends on an underlying response variable, which is that the expected utility from the positive participation of a smallholder irrigation scheme is greater than the utility of not participating. The random utility function ( $y^*$ ) for a farmer facing a decision to have positive participation and performance and contribute towards improving household income can be specified in equation 1.

$$y_i = 1 \text{ if } \gamma^* = i(x_i\beta + \varepsilon) > 0, 0 \text{ if otherwise } \gamma_i = 1 \text{ if } \gamma^*(x_i\beta + \varepsilon) > 0, 0 \text{ if otherwise...1}$$

Where

$Y$  is a dummy variable capturing farmers participation in the irrigation scheme (1 = if the farmer has participated and performed positively and well, 0 = otherwise),  $\beta = (\beta_0, \beta_1, \beta_2, \dots, \beta_6)$  is a vector of unknown parameters,  $i$  is the choice of the practice,  $x_i$  is a vector of covariates (explanatory variables), that is socioeconomic and demographic characteristics of the individual, and  $\varepsilon$  is the error term.

The empirical model that determines factors influencing the farmer's participation in the irrigation scheme is specified in Equation 2. A farmer ( $i$ ) decides to participate and perform well ( $Y_i$ ) if the expected utility from participating and performance in an irrigation scheme is positive. Farmer's participation and performance in irrigation schemes are associated with socioeconomic and institutional characteristics that can be described as follows:

$$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \dots + \beta_nX_n + \varepsilon_i \dots 2$$

Where:

$Y$  = If the farmer had positive participation and performance or not

$\alpha$  = Constant

$\beta$  = Coefficient of independent variable

$X_1$  = Age (year)

$X_2$  = Gender (1 if male or 0 if otherwise)

$X_3$  = Education level (number of years spent in school)

$X_4$  = Credit (1 if the respondent has access to credit, 0 if otherwise)

$X_5$  = Household income (actual amount)

$X_6$  = Farm size (actual hectares)

$X_7$  = Non-farm income (1 if non-farm income, 0 if otherwise)

$X_8$  = Extension services (1 if yes, 0 if otherwise)

$\varepsilon_i$  = Random error term

The marginal effects are estimated by differentiating Eq. (1) with respect to  $x_i$  according to Greene (2000).

$$\frac{\partial y}{\partial x} = \phi(\beta'x_i) \beta_i \dots \dots \dots 3$$

Where  $\phi$  represents the probability density function of the standard normal distribution.

### 3.4.2. Propensity Score Matching

The study adopted propensity score matching to estimate the impact of smallholder irrigation schemes towards enhancing household income in the study area. The propensity score matching (PSM) is defined as the probability that a person will receive an intervention (Kebede et al., 2021). PSM is a conditional probability that farmers adopt new technology, given pre-adoption characteristics (Mdoda et al., 2019; Christian & Mdoda, 2019; Jambo et al., 2021). Propensity score matching (PSM) refers to pairing treatment and control units with similar propensity score values, possibly other covariates, and discarding all unmatched units. The corresponding method has become more popular as a tool of impact evaluation. In the execution process, matching is done by creating a comparison group of individuals with observable characteristics similar to those of the treated. All treated observations are matched with households in the control group based on the weighted average. The weighted average is inversely proportional to the distance between the propensity scores of the treated and control groups. However, each treated observation is matched with a control observation as the closest propensity score.

Irrigation scheme participants were taken as the treatment group, and non-participants were taken as controlled or comparison group. Therefore, after matching, the difference between their incomes is calculated as the average effect of contract participation on the household income. The conditional probability of receiving a treatment given pre-treatment characteristics is as follows:

$$P(X) = P_r \{D = 1/X\} = E \{D/X\} \dots \dots \dots 1$$

Where  $D = \{0,1\}$  determines treatment exposure,  $X$  represents pre-treatment characteristics. The treatment effect reflects the variation in the welfare of irrigation participants and non-participants. Hence, farmers use irrigation  $T = 1$ , and who do not use irrigation  $T = 0$ .

$$T = Y_i(1) - Y_i(0) \dots\dots\dots 2$$

Let  $Y_i^T$  the amount of income by treatment group (irrigation user individuals), and  $Y_i^C$  The amount of income by the controlled group, then the difference in income between the treated and controlled group will be seen as:

$$\Delta_i = Y_i^T - Y_i^C \dots\dots\dots 3$$

Where  $\Delta_i$ , the change in income as a result of the treatment of irrigation.

Equation 4 represents the Average treatment effect for the population (ATE):

$$\Delta_{ATE} = E(\Delta_i) = E(Y_i^T / D = 1) - E(Y_i^C / D = 0) \dots\dots\dots 4$$

ATE shows the effect of income on households.

Where

$E(Y_i^T / D = 1)$ : Average income for individuals using irrigation ( $D_i = 1$ ) or with treatment.

$E(Y_i^C / D = 0)$ : Average income of households not using irrigation or without treatment. Then the average effect of treatment on the treated (ATT) will be:

$$ATT = E(E(Y_i^T - Y_i^C / D = 1)) = E(Y_i^T / D = 1) - E(Y_i^C / D = 1) \dots\dots\dots 5$$

In executing propensity score matching, the assumption of conditional independence and common support must be fulfilled. Conditional independence infers that observable characteristics and variables should merely influence treatment assignment (use of irrigation). At the same time, a common support assumption ensures that households with the same covariates' values have direct relations of being both users and non-users. The first step in the propensity score matching technique is estimating propensity scores. It is a single index number summarised from covariates

affecting an individual. However, an econometric model must be chosen before estimating propensity scores. The definitions of covariates are presented in Table 1 below.

### 3.5. Data and Sources of Data

The current study is based on household surveys conducted among smallholders in the Eastern Cape Province's two active and functional irrigation schemes (Tyhefu and Qamata). Key Informant Interviews (KIIs) with selected irrigation users and non-user farmers were conducted to supplement the household survey information. Farmers' livelihoods were used by household survey data using indicators that attribute the human, physical, natural, financial, and social capital (as shown in Table 1). In studying the impact of smallholder irrigation schemes on household welfare improvement of smallholder farmers, the variables of livelihood indicators in Table 1 were prioritised. The subject of inquiry was what happened to the welfare capitals of smallholder farmers who use smallholder irrigation farming compared to their non-user counterparts. The welfare in this study was conceptualised as a means of living in the form of productivity and farm returns. The study only selected the most important indicators attributing to welfare capital, which were carefully chosen from the literature and used accordingly. Table 1 shows the indicators characterising welfare capitals and their sources for this study.

**TABLE 1: Description of Variables, Unit and Expected Sign**

<b>Variable</b>	<b>Description</b>	<b>Variable type</b>	<b>Expectation sign</b>
Household Income (Dependent variable)	Total amount of all crop sales of the schemes (Rands)	Rand	+
<b>INDEPENDENT VARIABLES</b>	<b>Description</b>	<b>Variable type</b>	<b>Expectation sign</b>
Age	Age of respondents (actual years)	Continuous	+/-
Access to credit	Credit service (1=Yes, otherwise=0)	Dummy	+

Household size	Household members (actual numbers)	Continuous	+
Education	Years spent in school by households (in years)	Continuous	+
PARTIRR	Participation in irrigation (irrigation user=1, otherwise=0)	Dummy	+
DISMARK	Distance from the farm plot to the district market (in walking hours)	Continuous	-
SEX	Sex of the HHH (male=0, otherwise=1)	Dummy	-
EXTENSION	Number of visits by extension advisor	Continuous	+
CrTYPE	Number of crop types produced in the production year	Continuous	+
Livstock	Number of livestock in the household (TLU) (combined TLU: sheep, goats, cattle, pigs, chicken)	Continuous	+
MFRMO	Member of farm organisation (Yes=1, otherwise=0)	Dummy	+
MbilPn	Access to mobile phone for accessing agriculture and market information	Dummy	+
Farmex	Farm experience (Age as prox	Continuous	+
Offpar	off-farm job participation	Dummy	+

Owncultland	cultivated land	Continuous	+
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#### 4. RESULTS AND DISCUSSION

##### 4.1. Descriptive Analysis

The socioeconomic characteristics of smallholder farmers participating in irrigation schemes and non-users with comparison groups are presented in Table 2 below.

**TABLE 2: Socioeconomics Characteristics of Smallholder Farmers**

Variable	Participating in irrigation schemes, n=100	Non-participating in irrigation schemes, n=60	T-test
	<i>Mean</i>	<i>Mean</i>	
Gender: Males	0.68	0.58	2.667
Age of the farmer	0.45	0.48	5.321***
Access to extension services: Number of visits	7.34	6.27	1.678**
Member of Farm organisation: Yes	0.58	0.26	-2.654***
Education: Years spent in school	11.32	11.28	3.983***
Household size	4.23	3.89	0.560**
Off-farm participation	0.32	0.82	0.754**
Household monthly income	3 678.70	1 945.65	2.543**
Access to credit	0.54	0.38	-3.689***
Livestock owned	5.3	4.24	2.678
Farm experience	15.43	15.10	0.654
Farm size	1.54	1.48	0.456**
Distance to market	11.55	12.32	1.678

**Note: \*\*\* and \*\* show significance at 1% and 5% levels, respectively.**

The study results have found that smallholder farmers (63%) participate in irrigation schemes to enhance their livelihoods. These results were in line with Phakathi et al. (2021). They have governmental support, which is aligned with the South African Government's efforts to revitalise smallholder irrigation schemes in the country, which is seen as a suitable approach to improve the livelihoods of rural areas. The study results reveal that smallholder irrigation farming is dominated by male farmers (68%) and non-users (58%), respectively. This is not surprising given the cultural norms in Africa, where females take care of the family chores while men dominate the outside chores such as farming. These results were in line with Mdoda et al. (2022). The average age of participants (45 years) and non-users (48 years) was significant, implying that age is an important variable in the decision-making process for smallholder farming in the study area. This variable was also used as a proxy for farm experience. These results were in line with Assefa et al. (2022), who state that the majority of smallholder irrigated farming is practised by active and middle-aged farmers to engage with agribusiness to improve their welfare. The age demonstrates that smallholder farmers are active given their age, which is the middle-age, and they are energetic in doing things and participating in the farm's decision-making. The average household size was four persons per household in participating and non-user farmers. Household size was used as a proxy for family labour, and the household size provided farmers with family labour, which reduced the hiring costs as they did not pay them. The average number of years spent in school by smallholder farmers was 12 years, which is equivalent to secondary education in South Africa. These farmers were in line with Mujuru et al. (2022), Sigigaba et al. (2021) and Mdiya and Mdoda (2021) that smallholder farmers in the Eastern Cape Province are literate, which enables them the opportunity to access new innovative agricultural practices, market information and take well-informed decision regarding the farm as they are knowledgeable. This played an important role in smallholder irrigation farming as they have all the necessary skills and knowledge to operate farms and machinery to enhance productivity. The average farm size was 1.5 ha, suggesting farming was practised at a smallholder level. The land was the scarcest factor of production in the study area. These results aligned with Phakathi et al. (2021), who stated that smallholder irrigation in the Eastern Cape Province is practised at a smallholder level, given their input use and available farm size to farmers. The participating farmers in the irrigation scheme took farming as their main occupation, while non-users strictly depended on non-farm activities to generate income. These

results agree with Mdoda and Christian (2021) that farming among irrigation schemes is taken as an agribusiness.

The household monthly income varies among the farmers given their occupation; participating farmers in the irrigation scheme had a monthly income of ZAR3 678.70, which is made up of farm returns, social securities, and remittances, while non-users had a monthly income of ZAR1 945.65 which comes from salaries and other non-farm activities. Household income played an important role in farming, purchasing inputs, and paying transaction costs for transporting products to the market, as they had limited access to credit. Participating farmers had access to credit, but it was not enough to cover all farming operations. Smallholder farmers had access to extension services as they visit farmers on average about seven days a month to participate in irrigation schemes and six days for non-users, respectively. The participants in irrigation schemes were members of farm organisations who assisted them in information sharing and training, compared to non-users who were not members of farm organisations. Farmers were growing different crops such as maize, cabbage, spinach, potatoes, peppers, and onions, which they strictly sold to local markets and farm gates to generate income. Farmers have, on average, a minimum of total livestock units (cattle, sheep, goats, pigs, and chicken), and these were kept for income, source of drought power, source of protein, animal dung for organic fertiliser and means of transport. These results were in line with Assefa et al. (2022). The smallholder farmers travelled a long distance to reach the market and, on average, were 12 km from their farming site to the output and input markets.

#### **4.2. Factors Influencing Participation in Irrigation Schemes**

This section looks at factors influencing farmers' participation in irrigation schemes in the study area. Probit regression model estimated this and was fitting for the data as it has a probability level  $> \chi^2$  of 0.001 and a Pseudo  $R^2$  (0.861), which is 86%, meaning the model fits the available data used in the study. The variance inflation factor (VIF) is 1.75, indicating limited evidence of multicollinearity. These results fall within the rule of thumb of less than 10 specified by Gujarati (2009). Hence, the chosen observable characteristics adequately explain the probability of participation in Table 3.

**TABLE 3: Factors Influencing Performance of Schemes**

	<b>Probit results</b>		<b>Marginal effect</b>
<b>Variables</b>	<b>Coefficient estimate</b>	<b>P&gt; z </b>	<b>Coefficient estimate</b>
Age	0.0441	0.015***	0.041
Household size	0.0695	0.033**	0.035
Years spent in school	0.0754	0.028**	0.062
Access to market	0.0172	0.052**	0.054
Credit access	-1.5638	0.001***	0.028
Farm size	1.456	0.009***	0.024
Distance to output and input markets	-1.654	0.003***	0.054
Access to extension services	0.0542	0.023**	0.043
constant	-1.688518	0.068	
Number of observers = 160	Likelihood = -195.193118	Pr>Chi = 0.001 LR chi <sup>2</sup> (14) = 245.15	Pseudo R <sup>2</sup> = 0.861 Variance inflation factor = 1.75

**Note: \*\*\*, \*\* and \* means sign significant at 1%, 5% and 10% level respectively**

Table 3 above demonstrates factors influencing participation in irrigation schemes by smallholder farmers. The farmer's age had a positive coefficient and was statistically significant at 1%. This variable was important and agreed with the priory. This implies that a unit increase of one additional year in farmer's age will increase participation in smallholder irrigation farming. This implies that as the age of the farmers increases, their farming experience increases, and they will be capable of managing their farms effectively and making decisions that will improve their farming activities. These results were in line with Jambo et al. (2021) and Assefa et al. (2022) that having middle-aged farmers with richer farming experience is beneficial to the farm as it could be used efficiently to harness improved irrigation activity and welfare. The marginal effect of the farmer's age implies that a unit increase in farmer's age by an additional year will increase smallholder irrigation farm participation by 4%. This will ultimately improve smallholder farmer's welfare.

The household size was used as a proxy for family labour. Household size had a positive coefficient and was statistically significant at a 1% level. This variable was important for smallholder involvement in irrigation farming, providing farmers with family labour, reducing hiring costs. The results suggest that an additional member in the household will increase farm productivity and participation as extra hands can be used to work the land. The marginal effect results show that an additional household size member will increase smallholder farmers' participation in irrigation schemes and enhance their welfare. These results agree with Mujuru et al. (2022) that household size plays an important role in improving farmer's yields as it provides the farmer with additional hands which can be used on the farm, positively affecting smallholder farmer's participation in the irrigation scheme. The marginal effect also confirms that an increase in household size will increase smallholder farmer participation by 4% and enhance household welfare.

Years spent in school had a positive coefficient and was statistically significant at a 5% level. These results show a positive relationship between years spent in school and participation in irrigation farming. This implies that an additional year spent in school increases the participation of smallholder farmers in irrigation. This is the case because farmers have attained knowledge and technical skills to manage the farm and know what is needed to ensure the farm grows sustainably. Education is important in farming as it improves farmers' decision-making knowledge and adoption of new agronomic practices that will increase yields and farm returns. These results aligned with Phakathi et al. (2021) that increasing farmer's knowledge through improving farmer's knowledge is important in farming and agribusiness as it enhances farm returns and productivity. The marginal effect shows that an additional year spent in school increases the participation level of smallholder farmers in the irrigation scheme by 6%, and their household welfare is improved.

Access to markets and market information had a positive coefficient and was statistically significant at a 5% level. This implies that market access and market information enhance smallholder farmers' participation in irrigation schemes. This is the case in rural areas as it provides farmers with recent market information and encourages farmers to be involved in farming by ploughing crops that are demanded to enhance farm returns as they can reach markets with their produce. This was a very important variable for smallholder farmers. The marginal effect confirms that a 1% increase in market access and market information increases the participation of smallholder farmers by 5%.

Access to extension services is pivotal for participation in agribusiness and irrigation schemes. Access to extension services was positive and statistically significant at a 5% level. This implies that a unit increase in farm visits by extension agents will improve the smallholder farmer's participation in irrigation schemes. This is the case as they provide farmers with current information about new agricultural practices, updated financial support, and market information that will motivate farmers. These results aligned with Abdissa et al. (2017) and Assef et al. (2022). The marginal effect also shows that having access to extension services is important for farmer's development and participation in irrigation use by 4%.

Farm size is the most important factor of production. The farm size had a positive coefficient and was statistically significant at 1%. This implies that an additional hectare of farm size will increase smallholder participation in irrigation schemes to improve household welfare. These results were in line with Phakathi et al. (2021), who stated that having access to farmland improves participation in irrigation farming. The marginal effect also confirms that an increase in farm size by an additional hectare will enhance the participation of smallholder farmers by 2%.

Access to credit is the most important variable in purchasing inputs for the farm. Access to credit had a negative coefficient and was statistically significant at a 1% level. This implies that an increase of 1% in access to credit will reduce smallholder farmer's participation in the irrigation scheme. This is because smallholder farmers lack the financial support necessary to operate the farm, purchase inputs, and invest in new agronomic practices. The marginal effect shows that an increase in credit access will reduce smallholder farmers' participation by 3%. Distance to output and input markets had a negative coefficient and was statistically significant at a 1% level. This suggests that an additional one kilometre to the distance travelled to access output and input markets reduces smallholder farmers' participation in irrigation schemes. This is because farmers cannot afford the high transaction costs of reaching them as they are far from towns. These results agree with Assefa et al. (2022) that the farther away the farm is from the town and central business area, the higher the market and transaction costs constrain smallholder farmers. The marginal effect confirms that the additional kilometre travelled by the farmer decreases the participation of farmers by 5%.

### 4.3. PSM Results on the Effect of Participation in Irrigation Schemes by Smallholder Farmers

The study used PSM to estimate the impact of smallholder irrigation farming on household welfare. Table 4 below shows the PSM results. The welfare impact was measured in the form of household income from smallholder farmers' crop sales. The results from propensity score matching revealed that irrigation positively impacts household income. This provides sufficient evidence that irrigation schemes contribute to rural welfare through their effect on household income and food security. Therefore, the observed income gap (ATT) was ZAR 6301.745 (2.3%) due to irrigation access. The estimates for the average household income earned from irrigation participation range from ZAR 6301.745 to ZAR 6102.734, depending on the matching method used. All estimates are significantly different from zero at the 1% critical level. The result agreed with other studies that report a positive link between irrigation participation and income (Christian & Mdoda, 2019; Assefa et al., 2022; Adegbo et al., 2019; Sinyolo & Mudhara, 2018). This study indicates that irrigated farming has positively changed households' income, enabling them to send their children to schools, purchase inputs, use them for household expenditure in food and medical purchases and build assets.

**TABLE 4: Impact of Scheme on Sales Crop Income (PSM)**

Output variable	Kernel Matching Method		
	ATT	Standard error	P-value
Household income (ZAR)	6 341.745	453.107	0.023**
	Nearest Neighbours Matching Method		
	ATT	Standard error	P-value
Household income (ZAR)	6 102.734	429.636	0.055**
<b>Model Summary</b>	Number of observations =160    Matches requested    =5 Treatment model        = Probit		

Significant effects are indicated with \*\*:  $p \leq 0.05$ ; \*\*\*:  $p \leq 0.01$ .

## 5. CONCLUSION AND RECOMMENDATION

The study investigated the impact of smallholder irrigation schemes on household welfare, specifically on household income in farmer-managed irrigation scheme communities in the Eastern Cape Province, South Africa. Two groups of households were compared, namely irrigators and non-irrigators. It may be concluded that, even though some irrigation schemes collapsed, the operational irrigation schemes continue to play an important role in rural livelihoods. This provides a strong motivation for continued investing in smallholder irrigation schemes in South Africa as a part of the strategy to improve rural livelihoods and grow the rural economy. However, special attention should be given to significant factors that influenced participation in irrigation schemes and factors that significantly distinguished irrigators from non-irrigators. Participation in smallholder irrigation farming is rising in the Eastern Cape Province as farmers see it as an approach to enhance their household welfare. The study results reveal that smallholder irrigated farming is dominated by men with an average age of 45 years, which is an active and energetic age. Farming is the main occupation in the study area, and family labour reduces farming expenses. The probit regression results show that farm characteristics and socioeconomic and institutional factors mainly influence smallholder farmers' participation in irrigation farming.

The PSM results reveal that participating in smallholder irrigation farming positively contributes to farming and has enhanced farm returns immensely compared to non-users. The study concludes that participating in smallholder irrigated farming has improved household income for their welfare. This implies that the government should continue investing in irrigation schemes to grow the rural economy and improve rural livelihoods. This is in line with the Agricultural Policy Action Plan (APAP) and National Development Plan (NDP) of South Africa. Based on the study results, the study recommends that government and non-government organisations support smallholder farming by subsidising them with financial support, connecting smallholder farmers with the market and minimising their marketing costs, and providing training that will attract young people to form part of farming as a way of expanding irrigation farming. The study recommends building financial institutions and output markets close to the farmers' location to reduce transaction costs. Extension agents must increase farmers' awareness about participation in irrigation farming and provide other harmonising services that would enhance participation in irrigation farming to improve household welfare. Independent irrigators benefit more from smallholder irrigation farming, so independent irrigation should be promoted as an option for expanding smallholder

irrigation farming. Policies for expanding smallholder irrigation schemes should be integrated into the overall strategy of growing the rural economy within the country's national development plan.

This study aimed to assess smallholder irrigation schemes' contribution to rural households' livelihoods. Analysis of the data focused on the contribution of irrigation farming to household income and food security as the select livelihood outcome variables. Two groups of households were compared, namely irrigators and non-irrigators. It may be concluded that, even though some irrigation schemes collapsed, the operational irrigation schemes continue to play an important role in rural livelihoods. This provides a strong motivation for continued investing in smallholder irrigation schemes in South Africa as a part of the strategy to improve rural livelihoods and grow the rural economy. However, special attention should be given to significant factors that influenced participation in irrigation schemes and factors that significantly distinguished irrigators from non-irrigators.

This implies that the government should continue investing in irrigation schemes to grow the rural economy and improve rural livelihoods. This is in line with the Agricultural Policy Action Plan (APAP) and National Development Plan (NDP) of South Africa. Based on the findings highlighted above, it is recommended that addressing such barriers may create enabling conditions that would encourage households to access and participate more effectively in smallholder irrigation schemes and Policies that are in support of irrigation would also encourage more schemes to become irrigators are also vital. As independent irrigators benefit more from smallholder irrigation farming, independent irrigation should be promoted as an option for expanding smallholder irrigation farming. Policies for expanding smallholder irrigation schemes should be integrated into the overall strategy of growing the rural economy within the country's national development plan.

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