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Assessment of Decision-making in Rural Irrigation Schemes: A Case Study of Zanyokwe Smallholder Irrigation Scheme in Eastern Cape, South Africa

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ABSTRACT The researcher examined the farmers' participation in Zanyokwe smallholder irrigation scheme situated in Amathole district in Eastern Cape Province. The paper surveyed the households' willingness to continue participation in smallholder irrigation. The specific objectives of the study were to investigate the determinants of participation in the smallholder irrigation scheme, and to examine the relationship between household and farm characteristics. The paper adopted and used focus group discussions, structured and semi-structured questionnaires, interviews, observation and field measurement. The data was analyzed using the Statistical Package for Social Science (SPSS). The result shows that six out of twelve independent variables were found to be significant in explaining the households' choice to participate in the Zanyokwe smallholder irrigation scheme. The independent variables significant in the scheme were farm experience, farm asset, land rights, water sufficiency, marketing information, and produce variation/ yield gap, and the paper observed that there was general apathy towards the scheme owing to low crop yield. The average size of the food plots was grossly inadequate for households to realize higher production output. The paper concludes that training of beneficiaries on maintenance of farm infrastructures should be encouraged, and the marginal positive effect of increasing land size of beneficiaries will enhance participation in the scheme.

INTRODUCTION

Agriculture is the main stay for the South Africa economy and remains the principal livelihood of the majority of the poor rural community. Primary agriculture remains an important sector in the economy and it includes all economic activities from provisioning of farm inputs to farming and accounts for 3.9 percent of the Gross Domestic Product (GDP), while the Agro-food areas accounts for 3.9 percent (Terblanche 2008). South Africa is amongst the countries in the African continent that is endowed with natural resources but stagnation in agriculture has led to an increased poverty and food insecurity. The engagement of smallholder farmers into mainstream agricultural activities has been the government's priority, but hands-on empowerment remains rare. The use of smallholder agricultural practice and extension support in ameliorating poverty in the country is important given the enormous resources available in the sector. One of the ways to ensure the development of agriculture and improvement of production in the sector is the availability of extension support. The emphasis on extension support has been in the area of poverty alleviation, food security, employment creation, provision of raw materials and management of natural resources. The main potential to reduce rural poverty and inequality depends on the strong development of overall frameworks for the provision of social security, education and training, as well as healthcare, and in developing infrastructures in most rural areas (OECD 2014). South Africa has at least 330 smallholder irrigation schemes (SIS) situated mainly in the former homelands (Denison and Manona 2007) with seventy-nine percent located in Eastern Cape. In South Africa, the total land areas put under irrigation is approximately 1.3 million hectares with about 0.1 million hectares used by smallholder farmers (Backeberg 2006; Van Averbeke 2008). One of the reasons for the establishment of this SIS was to give farmers access to irrigated land with a view of

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improving rural livelihoods and increase crop production (FAO 2007).

The problem of low crop output worsened by poor farming methods has been noticeable in most irrigation schemes in South Africa (Crosby et al. 2000). According to Agholor (2014), about 30.83 percent of plot holders in Shiloh have taken inconsistent decisions in renting out their allocated food plots to a partner in a diary project for annual income. Optimal and proper decision-making is very important in smallholder agriculture and the improvement of quality decisions is a panacea to behavior modification. According to Janis (1972), decisional conflicts are an inconsistent phenomenon within an individual to either accept or reject a given path of action. In various cases such conflict becomes severe as the person making the decision becomes vigilant of the risk of running into problems. In decision-making, the decision maker tries as much as possible to achieve the best outcomes, purposes or aims. In some instances, the choice made by a decision maker may have a known outcome, which may be risk free or an unknown outcome, which may be uncertain. In a definite social situation, the likelihood of an alternative to be considered by a decision maker is influenced by the characteristics of the decision maker and the value committed to the alternative (Zeleke 2008). The conclusions from the study could be useful in assisting farmers towards making optimal and informed decisions in the smallholder irrigation scheme.

Objectives

The paper aimed at investigating the factors that influence participation of farmers in smallholder irrigation schemes and also examined the relationship between household and farm characteristics. In line with the reviewed literature, this study assumed that decision-making in smallholder irrigation schemes is critical and could negatively impact crop production. Therefore, the objectives of the study were:

1. To investigate the factors that influence participation in smallholder irrigation scheme.
2. To examine the relationship between household and farm characteristics.

Theoretical Framework

The theoretical framework of this paper is centered on the approaches of normative, descriptive and prescriptive (Bell et al. 1988; Edwards et al. 2007).

Normative Theory

The theory postulated that people make decisions that are built on the expected outcomes. In line with this assertion, an individual who makes decisions is perceived to behave rationally, examines the outcomes or consequences of each substitutes, prioritize the penalties before lastly making the best decision (Klein and Methlie 1990). Edwards and Fasolo (2001) observed that an ideal decision is usually determined quantitatively. The normative theory of decision-making process further illustrates that optimal decisions are centered on mathematical conceptions (Edward and Fasolo 2007). This approach lays emphasis on numerical reasoning. Hence statisticians accept decision-making in line with a normative viewpoint (Bell et al. 1988). Making choices from alternative decisions is dependent on rules referred to axioms, which guides a decision maker. Accordingly, the theory agrees that ideal decision should be guided by rules.

Descriptive Theory

This theory is also called the behavioral decision theory. It illustrates how a person integrates choice and information into the decision-making process (Fischhoff et al. 2008). In the descriptive theory, shortcuts, which are irrational or illogical (*heuristics*), may be taken to arrive at a decision. However, some shortcuts may be logically sound and real without bias to the choice an individual makes. Tversky and Kahneman (1974) further stated that irrational decision-making processes are good at times because the time and effort reduces in arriving at an acceptable decision. According to descriptive viewpoint, an array of childish decisions are bedeviled with bias and decreased long-term utility. Gladwin's (1980) "Theory of Real-life Choice" asserted that the descriptive method has been discovered to have an influence in the farmers' decision-making process.

Prescriptive Theory

The theory is anchored on assistance given to human beings in making informed decisions

by adopting the normative rules (Hucyznski and Buchanan 2001). In the prescriptive theory, farmers are equated to a scientist who prepares constructs or hypotheses in line with their belief and experiences within their environment. Starting with the prepared hypotheses, expectations are made congruent to the environment in which they operate and thereafter test these hypotheses against what they perceived to have happened (Murray-Prior 1998).

Hierarchical Decision Model

This model had a two-stage decision process as suggested by Gladwin (1989). The model assumes that alternative decision is made up of a set of 'aspects' (Gladwin 1980). An "aspect" is defined as a "dimension or feature of an alternative" (Gladwin 1980) and it also represents values, which are either measurable or not, for example, price, quality, or comfort (Tyersky 1972). Gladwin proposed that the decision-making process entails the division of all 'aspects' into categories. An 'aspect' such as insecurity of raising livestock may be considered as a constraint (for example, a farmer may conclude that a particular livestock is too unsafe to rear in his homestead) or livestock A is less unsafe to rear than livestock B.

METHODOLOGY

Population

The researcher conducted the study in Zanyokwe, which is located in the middle drift area of the Amathole district in Eastern Cape, South Africa. The smallholder irrigation scheme covers about 635 ha with 412 ha of irrigated plots and 97 plot holders. Sixty households in Zanyokwe smallholder irrigation schemes were therefore, considered adequate to balance the required level of reliability and cost. The 60 farmers were allocated serial numbers for ease of identification and analysis.

Sampling and Sample Size

The purposive sampling technique was adopted to select respondents for the study. The samples were obtained from the villages or locations served by Zanyokwe smallholder irrigation schemes, which includes Zingcuka, Kamma-Furrow, Ngqumeya, Zanyokwe, Lenye and Burnshill. The 60 plot holders selected comprised males and females.

Data Collection and Analysis

The structured and semi-structured questionnaires, interviews, personal observation, focus group discussions and some field measurements were used to collect data from the sampled households. The data was scrutinized and analyzed using descriptive statistics including, mean, standard deviation, and SPSS were also used to analyze quantitative data obtained from the sample households. The qualitative data was compared and carefully inspected for clarity. The determinants of decision-making of households were computed using the binary logistic regression. This approach was used because logistic regression allows for estimation of probabilities of events as a function of a set of explanatory variables that are hypothesized to determine an outcome (Pohlmann and Leitner 2003). The regression approach is commonly used to categorize individuals into one or two populations when only predictor variables are known.

The Model Used for the Study

The agricultural household model was used in the investigation of a smallholder farmer's decision-making. In limited subsistence circumstances, production and consumption decisions of households are often mutually dependent mainly because household labor is a key input for farming activities and the output from the household's production denotes an important share of the output used for consumption purposes (Amacher et al. 1999). Agricultural household model was founded on the literature of adoption and farm household (Feder et al. 1985) and (Singh et al. 1986). "The model showed that household maximizes utility (U) over a set of consumption items produced by a set of homegrown agricultural products (C_f), a set of consumption goods (C_{nf}), and leisure (l)." The utility from derived from household consumption and the stages or levels is dependent on the choice of its members (Ω_{HH}), shaped by the individualities or characteristics of the household, for instance the age, level of education and wealth rank of its members.

Factors that Influence the Farmers' Decision-making Process

The binary logistic regression model was used to assess the factors that influence the households' decision to remain and retain their food plots or move out of the scheme. The dependent variable, which was binary, assumes a value of 1 if a plot holder indicates his/her willingness to remain in the scheme and 0 otherwise. Using selected questions centered on the desire of the plot holders to remain in the scheme or not to remain in the scheme, two groups were created. The model used in this study as specified in equations 1.1 to 1.5 (below) examines the factors affecting the households' decision-making. According to Pohlmann and Leiter (2003), the logistic regression model estimate the likelihoods of an events as a function of a set of explanatory variables that are hypothesized to determine an outcome. There are no expectations or assumptions made with respect to the distribution of the predictor variables (X). However, X variables may be discrete or continuous (Afifi et al. 2004). The logistic regression approach is well established in empirical studies that seek to establish the determinants of decision-making in agricultural production (Mercer et al. 2005; Salam, et al 2000). Subsequent to Mercer et al. (2005), let R_i represent a dichotomous variable that would equal 1, if the households decide to remain in the scheme and 0 if they do not. The probability of the choice to remain in the scheme, $Pr\,(R_i=1)$, or not $Pr\,(R_i=0)$ is derived as follows.

The probability of choice to remain in the scheme is,

$$P = Pr\,(Ri = 1) = 1 = \frac{e^{(ß_0 + ß_1 X_{1i} + \dots + ß_k X_{ki})}}{1 + e^{-(ß_0 + ß_1 X_{1i} + \dots + ß_k X_{ki})}} \quad (1.1)$$

On the other hand, the probability of choice not to remain in the scheme is,

$$Pr\,(Ri = 0) = 1 - Prob\,(Ri = 1) = \frac{1}{1 + e^{(ß_0 + ß_1 X_{1i} + \dots + ß_k X_{ki})}} \quad (1.2)$$

Dividing [7.1] by [7.2], the researchers obtain,

$$\frac{Pr\,(Ri = 1)}{Pr\,(Ri = 0)} = \frac{Pi}{1 - Pi} = e^{(ß_0 + ß_1 X_{1i} + \dots ß_k X_{ki})} \quad (1.3)$$

Taking the log on both sides of Eq. [7.3] the results are,

$$In\left[\frac{Pr\,(Ri = 1)}{1 - Pr\,(Ri = 0)}\right] = ß_0 + ß_1 X_{1i} + \dots + ß_k X_{ki} \quad (1.4)$$

Where,

Subscript *i* represents *the* i^{th} observation in the sample

Pr is the probability of the outcome

$ß_0$ is the intercept term

$ß_1, ß_2 \dots ß_k$ are the coefficients associated with each explanatory (independent) variable X_1, $X_2 \dots X_k$.

The data considered in the model took into account farmers in the Zanyokwe irrigation schemes. The explanatory variables (X_i) included in the model were gender of household (GENDER), age of household (AGE), level of education (EDUC), farm experience (FARMEXP), land size (LANDSIZ), distance of household to the nearest access road (ROADDIS), land rights (LANRITS), farm infrastructure/asset (FARMASET), water sufficiency in the scheme (WATSUFC), access to extension service (EXTACES), marketing information (MKTINFO), and produce variation and yield gap (PRODVAR). The dependent variable used in this logistic regression analysis was whether or not the plot holders decide to remain in the scheme (DECREM), where DECREM = 1 if plot holder or farmers remain and 0 if they do not.

Following the above independent variables, the general form of Equation [1.4] was rewritten below to represent the probability of remaining in the scheme by sampled households in the Zanyokwe.

$$In\left(\frac{Pr\,(Ri=1) = \beta_0}{1 - Pr\,(Ri=0)}\right) + \beta_{1GENDER} + \beta_{2AGE} + \beta_{3EDUC} + \beta 4_{FARMEXP} + \beta_{5LANDSIZ} + \beta_{6ROADDIS} + \beta_{7LANRITS} + \beta_{8FARMASET} + \beta_{WATSUFC} + \beta_{10EXTACES} + \beta_{1MKTINFO} + \beta_{12PRODVAR}$$

RESULTS

With respect to the fitness of the model, the Leme show Goodness-of-Fit test statistics was 1.00, which implies that the model's estimates were appropriate to the data at a suitable level. Given that R^2 cannot be calculated exactly for Logistics Regression (Norusis 2004), a quasi R^2 was therefore worked out. In this paper, *Nagelkerke* R^2 was computed as a proxy estimate to R^2 in OLS regression, which measures the level of the differences in the response that is explained by the model (Norusis 2004). Fur-

ther, *Nagelkerke* R^2 of 0.608 was found, meaning that more of the variations were explained. The total percentage rightly predicted was 81.7 (Table 1). In the binary logistic used, six variables (farm experience, land rights/PTO, water sufficiency, farm asset, market information and production variation) out of the twelve predictor variables were found to have a significant impact on determining household decision-making, while six variables (gender, age, education, size of farm land, road distance and extension access) were not significant (Table 1). Of the six significant variables, two had positive signs (water sufficiency and farm asset), which implies that an increase in either of these variables may be associated with an increase in household decision-making. The other four predictor variables (farm experience, land rights/PTO, market information and product variation) had negative signs, which indicates an increase in either of these variables may be associated with a decrease in decision-making as illustrated in Table 1. The following are the major findings from the analyzed data.

Farming experience of respondents shows a significant relationship (*p-value* = 0.014) but negatively correlated to decision-making of households. The results suggest that for every unit increase in household farming experience, there is a 0.118 decrease in the log odds of decision-making. The farmers' view of land rights was also relevant and positively associated with decision-making of households to remain in the scheme (*P-value* 0.05). The results imply that for every unit increase in land rights, there are 0.013 corresponding increases in decision-making of households in Zanyokwe. The availability of farm assets (*p-value* = 0.014) was also significant and completely linked to decision-making. By implication, farm assets are relevant to decision-making. Further, water sufficiency was positive and significant in decision-making in the scheme with a *p-value* of 0.012. The results suggest that water sufficiency, as a variable is associated with decision-making of households. In Zanyokwe, market information (*p-value*: 0.003) was significant although negatively related to decision-making of households, while yield variation of farm produce (*p-value*: 0.001) also shows a significant but negative correlation to decision-making of households. The implication of these results is that for every unit increase in farm yield, there are 2.330 increases in the log odds for decision-making of households in Zanyokwe.

DISCUSSION

The result on farm experience was significant in decision-making of households. However, the result does not agree with the report presented by Enete et al. (2002) that experienced farmers are better in quality decision-making. Nonetheless, farmers with few years of experience may have a wider range of skills, greater understanding concerning farming systems and may be skillful in evaluating risk. The farmers' perception of land rights was significant and

Table1: Determinants of decision making for choice to remain in the scheme (Zanyokwe)

Independent variable	*B*	*S.E*	*Wald*	*df*	*Sig.*	*Exp(B)*
Gender	.35	.613	.341	1	.559	1.431
Age	-.039	.044	.800	1	.371	.962
Educ	.155	.263	.346	1	.556	1.168
Farmexp	-.118	.081	2.096	1	.014*	.889
Landsiz	.013	.277	.002	1	.963	1.013
Roaddis	-2.008	1.083	3.436	1	.064	.134
Lanrits	-.439	.659	.444	1	.01*	.644
Watsufc	2.197	.877	6.276	1	.012*	9.000
Farmaset	1.993	.810	6.049	1	.014*	7.34
Extaces	1.026	.586	3.066	1	.080	2.790
Mktinfo	-.807	.645	1.567	1	.003**	.446
Prodvar	-2.330	.699	11.121	1	.001**	.097
-2 Log likelihood	40.819[a]					
Nagelkerke R^2	.608					
Percentage correctly predicted	81.7					

Note: *Significant variables influencing decision making at 0.01(**), and 0.05 (*) levels of significance.

positive in the households' decision-making. This positive result is consistent with the studies by Bannister and Nair (2003) in Haiti who emphasized that farmers cultivated more trees on plots where they had tenure security. In addition, a number of studies maintained that in situations of insecure tenure, the risk related with losing land would discourage farmers from making investments. According to Carter and Olinto (2003), more significant investment happened with farmers that had property rights than those farmers that did not. The availability of farm assets recorded a significant and positive value in decision-making of households. One of the themes that developed from the focus group discussions was the inadequate farm asset. Farmers claimed that this was the primary factor influencing decision-making in the schemes. Water sufficiency was positive and also had an impact on decision-making in the scheme. The result from water sufficiency is not shocking because from the focus group discussion held, Kamma-Furrow and Lenye North used paid electricity to pump water to their crop fields. This result is also consistent with the reports of Stephen (2007) and Monde et al. (2005) that decreased level of crop yield in many smallholder irrigation schemes in South Africa stems from inefficient water use. Furthermore, market information was significant but negatively related to decision-making. This result was also predicted mainly because the farmers were not dissatisfied with their existing access to market information. The main concern here was proximity. The marginal effect revealed that the probability of participation in the irrigation scheme is higher for households with a good access to market information than households without access. The yield variation of farm produce was significant but negatively related to decision-making of households. The finding however, is consistent with the report of Darr and Uirbrig (2004), who found that households that continued tree planting in the "tree-planting program" were farmers that derived greater returns on their agricultural output.

CONCLUSION

Several households depend on smallholder irrigation schemes as a means of livelihood but many have developed lethargy owing to low crop yield attributed to a mirage of constraints. From the results of the study, it is implied that smallholder decision-making is influenced by the factors included in the model. In the model adopted, six out of twelve independent variables were found to be significant in explaining the households' choice to remain in the Zanyokwe smallholder irrigation scheme. The independent variables significant in the scheme were farm experience, farm asset, land rights, water sufficiency, marketing information, and produce variation/yield gap. The results imply that the logistic regression model describing the householders' choice to remain in the scheme conforms to some of the described variables in the study.

RECOMMENDATIONS

From the findings of the study it is recommended that regular training of smallholder farmers on maintenance of farm infrastructure should be reinvigorated. The size of food plots allocated to most households in Zanyokwe was grossly insufficient for households to obtain higher production output. Therefore, the researchers assume a glaring positive effect of increasing land size on the possibility of farmers continuing with the scheme. The implication here is that encouragement of households through proper land allocation procedures should be put in place. Low crop yield in many smallholder irrigation schemes in South Africa have been attributed to low water use efficiency, amongst other factors. With the growing shortages of water and the inefficient use of water, the need to increase water use efficiency is paramount. Irrigation scheduling, which will enhance water use effectiveness should be implemented. Farmers' participation in decision-making regarding issues that influences their well-being, is important to enhance collective responsibility for outcomes achieved. Therefore, it is recommended that farmers be involved in the program planning cycle for sustained adoption of innovation and technologies. For this to happen, it is important that the government should institutionalize participatory extension approaches in order to increase the farmers' participation. As a result, this study recommends and encourages the government to develop a strategic Smallholder Investment Plan, which would improve investments in smallholder agriculture.

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