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Sustainable Water Conservation Practices and Challenges among Smallholder Farmers in Enyibe Ermelo Mpumalanga Province, South Africa

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Abstract

The study examined the adoption of water conservation practices and challenges encountered by smallholder farmers in water resource conservation in Enyibe, Ermelo South Africa. The data were collected using structured questionnaires, observation and focus group discussion. Frequency, mean and logistics regression were used for data analysis. Age ($\beta=1.238$), sex ($\beta=-1.497$), level of education ($\beta=-1.062$), access to irrigation facilities ($\beta=1.690$), payment of water tariff ($\beta=1.369$) and agricultural extension advice ($\beta=-.631$) were significant and associated with adoption of water conservation practice. The identified constraints in the adoption process were inadequate technical guidelines, financial, government policies, and inadequate knowledge of water conservation practices. There is need to improve information, showcase the benefits of water conservation, and ensure maintenance of water conservation infrastructure. Concerted effort must be made to establish robust database on water resource conservation and sources of water utilised in the area.

Keywords: Sustainable, water conservation, constraints, adoption

Introduction

The promotion of water resource conservation has been a major issue in the light of growing population, migration of rural dwellers to urban centres and urbanization leading to increased demands for water resources. While agriculture remains the largest consumer of the world's freshwater resources, more than a quarter of energy consumed globally relates to food production (UN, Water 2019). South Africa is going through a transformative period of unprecedented economic modifications at a time when water resources are fast depleting following the advent of extreme climate change. The growing scarcity of water resources is the greatest threat to the attainment of the 2030 Agenda of the Sustainable Development Goals (SDGs). Water shortages pose problems to sustainable agricultural development but if it is

managed effectively, it can increase resilience to social, economic and environmental issues resulting from climate event. The one-sided approach to water management in agriculture which includes rational water supply, supply of water infrastructure and technical modifications are grossly inadequate to enhance sustainability of water resources in South Africa. The need to complement numerous demands and sources of water within the economic, environmental and social context is paramount (Water Green Cape, 2019). Furthermore, cost recovery and maximization have over the years shifted to soft infrastructures like meters, streams gauging, water reporting systems, farm surveys, and benchmarking of irrigation with no recourse. The gap in awareness, inadequate scientific know-how in monitoring the hydrological cycle further compounds the problem thus pushing water resources into an era of uncertainty and risk (Matchaya *et.al*, 2019).

Water resource entitlement and pricing requires timing and management of flows in rivers and volumes of dams with thorough monitoring of extractions. Nevertheless, a sustainable water entitlement approach requires good skill on river health and hydrologic assessment. This primary information is usually not accessible, but without it, improvement and enhancement of water resources remains blink (Organisation for Economic Co-operation and Development, 2015). The need for information on economic principles of water resource use should also be prioritized to allow routine maintenance of irrigation infrastructures and cost sharing measures between irrigators and public suppliers of irrigation. In South Africa, most smallholder irrigation schemes lack adequate farmers' participation and a well-developed human capital to effectively maintain irrigation infrastructure and conserve water (Agholor, 2014). However, in achieving a sustained water regime, revitalisation and the development of water resources action plan must be put in place. It is only then; will South Africa be seen as promoting sustainable water conservation practice. Though, much seems to have been achieved in the water sector since post-independence in South Africa, the water conservation approach has been inadequate. In addition, most farmers in South Africa still practice crude traditional methods of cultivation with no conscious effort of adopting water conservation techniques (Mucave, 2013).

A major concern is the degradation of land and water resources which ultimately jeopardize environmental and agricultural sustainability in South Africa. Neglecting appropriate water conservation practice, will amount to food shortages and loss of farm income. In this period of erratic climate events, the adoption of sustainable water conservation techniques has become a national development policy discourse for South Africa, notably as an avenue to assuage the envisaged disaster of food insecurity.

The adoption of water conservation practices which include among others, mulching, rainwater harvesting, contour ridges and terraces must form part of the development initiatives for agriculture in the study area. Nevertheless, farmers encounter numerous constraints like unstable agricultural policies, scanty knowledge of a known conservation practice and inadequate research to justify the use of a

particular conservation practice. Furthermore, the adoption of water conservation practice remains indeterminate and low in most communities (Matchaya *et.al.*2019) despite concerted efforts to encourage farmers in South Africa.

However, the constraints to adoption remains problematic. The paper examined the adoption of water conservation techniques and challenges encountered by smallholder farmers in water resource conservation in Enyibe, Ermelo South Africa. The objectives of the study were to: Examine the dependence of adoption of water conservation practices on selected socio-economic characteristics of respondents; highlight major constraints of smallholder farmers in developing resilience during adverse weather event in Enyibe, Ermelo, South Africa.

Methodology

The study was conducted in Enyibe Ermelo, Msukaligwa Local Municipality which is one of the seven local municipalities within the Gert Sibande District Municipality, Mpumalanga Province of South Africa (Figure 1). It is geographically located at latitudes -26° 32' and 59.99" South and longitudes 29° 09' and 60.00" East. The study area is predominantly peri-urban with a population of 149,377 people and it covers 6,016. The racial makeup is predominantly black African at 88.1% and 72.6% Zulu speaking (Stats SA 2015).

Farm household population was 125, separated and considered as a unit for the purpose of this study. The sample size was collated using 5% margin of error with 95% confidence interval. In consideration of this set values, a sample size of 100 smallholder farmers was obtained and considered adequate for this study. The questionnaire was administered to the respondents with the assistance of trained enumerators between the month of May and September 2019. Furthermore, pre-test of the questionnaire with 20 selected smallholder farmers was done. Mean, standard deviation, percentages were employed. Crosstab was used to explain the variations in socio-economic demographics of respondents' in relation to adoption of water conservation techniques. Finally, IBM-SPSS statistics software was used to analyse all data. Logistic regression was used for this study because it is suitable when predicting dichotomous variable from a set of predictor variables as in the case of this paper. The dependent variable was binary with an assigned value of 1 if a particular smallholder farmer adopted water conservation practices and 0 otherwise. However, the independent variables were operationalized as follows:

Table 1: Operational description and measurement of variables

Independent variable	Operational description	Type of measurement
Age	The number of years a person has lived	1= 20 -30; 2 = 31 - 40; 41 – 50..... 6 = 71 and above.
Sex	Household: Male or female	1 = Male; 2 = Female
Education	Level of education achieved	1 = No school; 2 = primary school; 3 = secondary school; 4 = tertiary
Marital status	The state of being married or not married	1 = Married; 2 = Single; 3 = Widow; 4 = Widower; 5 = Divorced
Employment status [off-farm activities]	Working	1 = employed; 2 = self-employed; 3 unemployed
Source of water	Where water is obtained for household use	1= tap water; 2 = Dam; 3 = borehole; 4 = river; 5 = other
Irrigation method	The type of irrigation system used in the farm	1 = watering can; 2 = Drip irrigation; 3 =Sprinkler; 4 = other
Irrigation access	Access to irrigation facility	1= yes; 2 = No
Water tariff	Indication as to whether tariff is paid or not	1 = yes; 2 = No
Extension services	Availability of agricultural Extension services to households	1 = yes; 2 = No

The logistic regression analysis was computed as follows: let Y_i represent a dichotomous variable that would equal 1, if households' adopt water conservation practices and 0 otherwise. The probability of adoption of water conservation practices, $Pr(Y_i=1)$, or not $Pr(Y_i=0)$ is achieved thus:

The probability of adoption of water conservation practices is:

$$(1) \quad P = Pr(Y_i = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}} = \frac{e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}}{1 + e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}}$$

On the contrary, the probability of not adopting water conservation practices:

$$(2) \quad Pr(Y_i = 0) = \frac{1 - Pr(Y_i = 1)}{1 + e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}} = 1$$

Dividing [1] by [2]:

$$(3) \quad \frac{Pr(Y_i = 1)}{Pr(Y_i = 0)} = \frac{P_i}{1 - P_i} = e^{(\beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki})}$$

Taking the log on both sides of Eq. [3], results:

$$(4) \quad \ln \left[\frac{Pr(Y_i = 1)}{1 - Pr(Y_i = 0)} \right] = \beta_0 + \beta_1 X_{1i} + \dots + \beta_k X_{ki}$$

Where:

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

Pr is the probability of the outcome or result

β_0 is the intercept term

$\beta_1, \beta_2, \dots, \beta_k$ are the coefficients of the independent variables X_1, X_2, \dots, X_k .

The resultant equation is thus presented as follows:

$$(5) \quad \ln \frac{Pr(Y_i = 1)}{1 - Pr(Y_i = 0)} = \beta_0 + \beta_1 AGE + \beta_2 SEX + \beta_3 EDUC + \beta_4 \dots \beta_n X_i$$

Measurement of Variables Used to Determine Level of Constraints in the Use of Water Conservation

The Likert-type scale was used to measure the constraints of inadequate technical guide, financial constraints, constraints of government policies and inadequate knowledge. The three point Likert-type scale used were coded as, low constraints (LW) =1, medium constraints (MC) =2 and high constraints (HC) = 3 respectively. The standard deviation and mean of the variables associated with the measurement was realized and was ranked as follows: 1+ 2+ 3/3 =2.00. However, with a confidence interval of 0.5, the low level limit of constraints is 2-0.5 = below 1.5, medium level of constraints is 2.0 + 0.5 = 2.5 and above as the case maybe.

Results and Discussion

Dependence of Adoption of Water Conservation Practices on Socio-Economic Characteristics

Table 2, depicts the dependence of adoption of water conservation practices on socio-economic characteristics. About 50% of the respondents were between 18 –

35 years old while 47% (36 – 49 years old) and 36% (50-60 years old). Finding reveals that able-bodied men and women were dominant in the area. This finding is not surprising because from the focus group discussion with respondents, found that older farmers were conspicuously present and contributed during the session. This result lends credence to the finding of Gima (2017) that older farmers with long years of experience adopted innovation better than the younger ones.

Finding reveals that about 21% of male and 39% of female respondents adopt water conservation practice. Moreover, finding also reveals that 8% of respondent had no formal education while 27% had primary education. However, 50% of respondents had secondary education while 67% had tertiary education. The implication here, is that respondents who had higher level of training and education were in the category of adopters of water conservation practice. This finding is supported by the study of Hoang, G.H. (2020), found that educated farmers appreciate and adopt the use of mobile phone in marketing cereals than the uneducated farmers. Furthermore, result shows that 33% of respondents were married while 50% were single. Also, 22% were divorced and 17% were widow. Household demographics play an important role in understanding diversity inherent in agricultural activities. This result is in consonance with the study of Pienaar and Traub (2015), found that social relations such as gender, marital status, class differences are central to agricultural production. Also the study of Agholor (2019) found that almost 43% of the labour force in Sub-Saharan Africa’s agricultural sector are made up of women, but their activities in farming are reduced to unpaid family labour, and as a consequence, they are in many cases excluded from agricultural statistics.

Table 2: Dependence of adoption of water conservation practices on socio-economic characteristics

	Socio-demographic characteristics of Adopter of water conservation practices			
Age	18-35	36-49	50-60	≤61
	50%	47%	36%	-%
Sex	Male	Female		
	21	39%		
Level of Education	No school	Primary	Secondary	Tertiary
	8%	27%	50%	67%
Marital status	Married	Single	Divorced	Widow
	33%	50%	22%	17%
Employment (off-farm activities)	Employed	Unemployed	Self employed	
	41%	24%	34%	

Some of the respondents (41%) were employed in off-farm activities, 24% were not employed in off-farm activities, and 34% of the respondents were self-employed in

off-farm activities. The respondents' livelihood structure was relatively many-sided, involving cultivation of crops, rearing animals, hawking, running Spaza shops and related off-farm activities like engaging in menial jobs. Agholor, (2014) argued that intensive production of vegetables throughout the year, were not achievable in Shiloh and Zanyokwe smallholder irrigation schemes mainly because of off-farm activities. Farmers who engage in off-farm activities may be distracted, leading to no knowledge and adoption of water conservation technology.

Factors affecting Adoption of Water Conservation Practice

Table 3 shows the logistics regression result of variable factors associated with adoption of water conservation practice.

Table 3: Adoption of water conservation practices

Step	Adoption (% Yes)	-2 log likelihood	Cox & Snell R	Nagelkerke R ²
1	58.8	77.182 ^a	.459	.612
5	58.8	78.560 ^a	.452	.602

Scrutinizing the model used, a *Nagelkerke R²* of 0.612 for step 1 and 0.602 for step 5 were obtained with overall correctly predicted percentage of 82.0% (Table 3). This implies that the model appropriately explained the variables in the equation as computed. Conversely, by employing a .05 criterion of statistical significance, age, sex, level of education, access to irrigation facilities, payment of water tariff and agricultural extension services had significant influence in the adoption of water conservation practice as discussed below.

The age of the respondents was significant with coefficient of 1.238 and positively associated with adoption of water conservation practice (Table 4). This outcome suggests that when all variables are held constant, the adoption of water conservation practice is more likely to increase by 3.448 (odd ratio) times as age increases. The plausible justification of this result is that older farmers with sufficient farm experience are easily inclined and eager to gather information from various sources. Subsequently, they tend to be well-informed of innovations in agricultural practices much more than the younger farmers. This result is consistent with that of Mango *et.al*, (2017), found that a one-year increase in age was associated with a 3% increase in the probability of adoption of available soil and water conservation practice in Chinyanja, Southern Africa. The sex of the respondents was significant with coefficient of -1.497 indicating that the log odds of adoption of water conservation practice by females is .224 times more than the males. This finding is corroborated by Daudu *et.al*, (2019) in their study of differences in entrepreneurial diversification among male and female rural farming households in Kwara State, Nigeria found that majority of the females were proactive and tend to create more innovative undertakings than males. In a similar study by Quisumbing *et. al*. (2014)

found that empowered women who make decisions about farm inputs were more productive in agricultural activities than men.

The level of education recorded a coefficient of -1.062 and is associated with the adoption of water conservation practice. This results suggest that, a one-year increase in the number of years the farmer attended formal education, increases the log odds of adoption of water conservation practice. This finding imply that as the level of education of farmers increases, the rate of adoption of water conservation practices also increases. The relevance of education in behaviour change cannot be over-emphasised as a measure for agricultural sustainability in Enyibe, Ermelo South Africa. This finding is supported by numerous other studies (Kadafur *et.al*, 2020), found that educated households are more disposed to information and are, able to adopt new technologies.

Also, access to irrigation facilities with a coefficient of 1.690 increases the log odds of adoption of water conversation practices. Findings reveal that for every unit increase in access to irrigation, there are 5.419 increases in the adoption of water conservation practice. The implication here, is that some farmers in Enyibe Ermelo South Africa use irrigation infrastructures and are therefore, acquainted with water scheduling events commonly enforced. These farmers are better able to accept and adopt water conservation practice primarily because of their understanding that water is a scare resources in the area.

Payment of water tariff had a coefficient of 1.369 and associated with adoption of water conservation practices. The likelihood is that for every increase in the amount of water tariff there are 3.929 increases in the adoption of water conservation practice. This imply that enforcing water tariff regime is relevant and could motivate the consciousness of farmers in water conservation initiative. The management of water resources entails unrelenting efforts and commitment of farmers and the society.

The log odds of adoption of water conservation practice was also found to be associated with agricultural extension advice with a coefficient of -.631. The results suggest that for every unit increase in access to extension services there are .532 times increases in the adoption of water conservation practice. Agricultural extension services play a unique role in information dissemination, networking and adoption of innovation. Result is corroborated with the findings of Nyangena and Juma (2014), found higher adoption intensity by farmers as a result of increased awareness and knowledge impacted by extension advisors.

Table 4: Determinants of adoption of water conservation

Independent variables	B	S.E	Wald	Exp(B)
Age of respondents	1.238*	.399	9.624	3.448
Sex of respondents	-1.497*	.642	5.435	.224
Level of Education	-1.062*	.382	7.734	.346
Marital status	-.079	.410	.037	.924
Employment status	.240	.470	.261	1.271
Source of water	-.217	.407	.285	1.271
Method of Irrigation	-.292	.353	.684	.747
Access to irrigation facilities	1.690*	.767	4.850	5.419
Payment of water tariff	1.368*	.692	3.910	3.929
Agricultural Extension services	-.631*	.327	3.709	.532

*P≤0.05

Main Constraints to Water Conservation Practices

Table 5 shows the constraints experience by farmers in the application and use of water conservation in Enyibe Ermelo. These constraints are as follows:

Table 5: Main constraints in the used of water conservation techniques

Main constraints (n=100)	Mean \bar{x}	Std. Dev.	Rank
Financial constraints	2.78	.416	1 st
Constraints of government policies	2.58	.654	2 nd
Constraints of inadequate knowledge of water conservation practices	2.45	.770	3 rd
Constraints of inadequate technical guidelines	2.37	.646	4 th

Inadequate Technical Guidelines: The constraints of inadequate technical guidelines recorded a mean value of 2.7 and ranked fourth in the category of constraints. Farmers asserted that they need sufficient information and training, suitable guidelines and regulatory frameworks, and incentives to enhance adoption of water conservation practice. Result found that available water harvesting methods used for water conservation have been designed in a “one size fits all” coupled with inadequate technical guide on water harvesting technology. Respondents affirmed that the available water harvesting technologies not only lack technical guides but also were not user friendly. Crafting of suitable technology with appropriate guide and user friendly for females and males must be taken into consideration. This finding is supported by the study of Perez *et.al*, (2015), found that the reliance on human power over technology and inadequate guide for a large range of farming activities continues to be a fact of life for rural communities.

Financial constraints: Financial constraints had a mean of 2.78 and ranked first by the respondents with a standard deviation of .416 on the category of constraints. The financial cost of constructing and maintenance of water harvesting equipment is a determinant of water conservation practice at farm level. Most farmers do not have the manpower available to remove large amounts of soil that is necessary in some of the water harvesting systems in use. Farmers affirmed that money is required to successfully create initial investment into land preparation for water conservation. However, most farmers are constrained financially, and many declined to adopt even though they are aware of the embedded benefits of water conservation. This finding is supported by the finding of (Oladipo *et al.*, 2020), that farmers' adoption of bio-security practices in Jigawa State, Nigeria were dependent on available financial resources.

Constraints of government policies: Water conservation practice have not been backed up by suitable policies and institutional support in South Africa. South Africa, like many other countries in the region has no clear government policies and legislation on the use of in-field water harvesting (Water Research Commission, 2013) Besides, smallholder farmers remain at the "tail-end" of policy making, and in most cases, policies are designed without proper consultation with farmers. In addition, there are no incentives that are given to farmers who take up innovative ideas in-field water harvesting. Finding reveal that constraint of government policies recorded a mean of 2.58 and ranked second on the category of constraints. However, studies are silent on the benefits of adopting improved water harvesting, which hitherto include increased yield and improved food production. There are unintended effects of the agricultural policy and may include conflicts and disagreements amongst farming household (Jat, *et.al*, 2014). However, agricultural policy has great potential to enhance productivity of households given that principles embedded in polices promote the transition of agricultural sector toward improved livelihood.

Inadequate knowledge of water conservation practices: The more awareness and experience farmers have about water conservation (WC), the more convinced and certain about their adoption. On the contrary, the less experience and knowledge farmers have with WC, the more negative in their attitude to adopt. The mean of 2.45 is a clear indication that most farmers in Enyibe Ermelo have no sufficient knowledge of water conservation hence there was low level of adoption. In the study with European and American 'no-till farmers' came to similar conclusion. From the focus group discussion shows that farmers without practical experience in CA, advanced many problems for non-adoption. Water conservation is seen as a complex system and knowledge-intensive to grasp and implement in the area. The primary aim of water conservation is to mitigate the effects of water shortages for both household needs as well as for productive and future use. Water conservation has been used to improve access to water and sanitation, improve agricultural production and health care thus contributing to poverty alleviation, and

enhance reforestation and improved agriculture production (Water Green Cape, 2019).

Conclusion and Recommendation

Age, sex, education, access to irrigation, payment of water tariff, and agricultural extension advice were positively associated with adoption of water conservation. However, the main constraints encountered by farmers in the adoption of water conservation were inadequate technical guidelines, financial constraints, constraints of government policies and constraints of inadequate knowledge of water conservation practices. There is the need to improve information, showcase the benefits of water conservation, and ensure maintenance of water conservation infrastructure. Concerted effort must be made to establish robust database on water resource conservation and sources of water utilised in the area.

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