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Climate-Smart Agriculture and Smallholder Farmers' Income: The Case of Soil Conservation Practice-adoption at Qamata Irrigation Scheme, South Africa

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ABSTRACT This paper evaluates the influence of the adoption of climate-smart agricultural (CSA) practices on smallholder farmers' overall income, using the case of soil conservation practice-adoption at Qamata Irrigation Scheme (QIS), South Africa. Employing the case study research design, data were collected from seventy smallholder farmers at the scheme (QIS), and analysis was with the multiple linear regression model because the dependent variable was continuous in nature. According to results, older farmers had more likelihood for increases in overall income. Also, farmers who were aware of recommended practices, were more likely to have increases in their overall income. Similarly, female-headed households and farmers who hold a negative perception of extension recommendations had higher probabilities for increased overall income, which were both unexpected. The conclusion is that the adoption of CSA/soil conservation practices by smallholder farmers at Qamata Irrigation Scheme has significant influence on farmers' overall income in the study area.

INTRODUCTION

Farmers in Africa, like their counterparts in other parts of the world are confronted with the problem of increasing temperatures and more instances of weather extremes due to climate change (Girvetz et al. 2019). The reality of climate change is no longer a debate. It is now observed all over the world (Yildiz 2019). Since 1975 when increases in temperatures became obvious, temperatures here in Africa have steadily increased at a rate of about 0.03°C per annum (National Oceanic and Atmospheric Administration [NOAA] 2018). In the last two decades, temperature records are being constantly broken. For instance, 19 of the past 20 years have been hotter than any preceding year on record and predictions are that with current rate of increase, Africa would be heated up by 1.7°C by 2030s and 2.7°C by the 2050s (Girvetz et al. 2019). Similarly, historic precipitation patterns show that many parts of Africa are drying up (Hartmann et al. 2013).

Changes in temperature and precipitation patterns are a huge threat to agricultural development. According to Yildiz (2019), climate change is actually already happening and it is a current challenge to agriculture. The above changes have immediate and long-term implications for food security all across Africa (Niang et al. 2014) and the rest of the world. Any disturbance to agricultural systems, whether in the form of crop failures, yield losses, soil degradation, can instigate multiplier effects, causing fluxes in local economy, volatility in global commodity markets, and a reduction in food security (Bitterman et al. 2019) and income. The vulnerability of agriculture to climate is one of the greatest problems confronting sustainable global food systems (Mase et al. 2016).

Smallholder farmers suffer more from any shocks from climate change due to their peculiar characteristics such as small farm sizes, inadequate capital, little access to market information, and low bargaining power. Generally, the poor and the marginal income groups are mostly affected by extreme systems shocks, which in-

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cludes shocks from climate change (Paris and Rola-Robzen 2018). Anuga et al. (2019) opined that smallholder farmers, especially from underdeveloped areas, are the most vulnerable to effects of climate change because of high levels of low adaptive capacities by such farmers. According to FAO (2017), agriculture in Africa is particularly vulnerable to effects from climate change and variability because its agricultural system is largely rain-fed and there is inadequate 'shock-absorption' due to the fact that productivity is already low. A good example of this vulnerability was experienced in southern Africa in 2019 where Mozambique, Malawi and Zimbabwe were hit with deadly storm that claimed hundreds of lives and eroded agricultural land, creating immediate food crisis in these countries.

Africa has been noted as the continent most susceptible to climate change (World Bank 2013; Niang et al. 2014). One main reason is because majority of African population live directly or indirectly on agriculture, largely in smallholdings. Girvetz et al. (2019) maintained that climate change is expected to impact more negatively on the livelihoods and food security of such farmers. In South Africa, the Financial and Fiscal Commission of the Republic of South Africa (FFC 2015) emphasized that climate change impact is a great challenge for the whole South Africa, especially the vulnerable households in rural areas. Similarly, Schulze (2016) posited that everyone in South Africa is already facing the negative impacts of climate, ranging from severe floods to extreme heat and drought to increased problems caused by wildfires, disease and pests. The FFC (2015) report further highlighted that amongst all provinces, households in the Eastern Cape (one of the three poorest provinces in South Africa), where this study was conducted, is more vulnerable to climate change effects. This supports the view that the poorest of population suffer most from effects from climate change. Hence, the adoption of CSA might be an innovative measure to mitigate climate change for the benefit of the poorest of the population.

Climate-Smart Agriculture (CSA) and Soil Conservation Practices

CSA is defined as an agricultural measure which aims at achieving (a) sustainable increase in farmers' productivity and incomes; (b) adapting and being able to build resilience to climate change; and (c) where possible, reduce and/or eliminate greenhouse gas emissions (GHG) (Gerber et al. 2013; FAO 2017; Paustian et al. 2016). As a panacea for climate change, CSA is being promoted globally as a mitigating agricultural strategy for sustainable food security (Biowatch South Africa 2015). Apart from the debate around 'what CSA is, and what it is not', the approach to agriculture is progressively being advocated and endorsed by national, regional, continental and global authorities (Girvetz et al. 2019), due to its immense benefits. CSA is not a set of applicable universal practices per say, but an approach which consists of different elements in a local context (Campbell et al. 2014; FAO 2017). Schaafsma and Bell (2018) maintained that CSA is a system of agriculture where several practices are mixed. The mix therefore depends on suitable and adaptable elements in a particular local environment. Hence, CSA is situation/location-specific.

Although Shea (2014) suggested that CSA involves developing new technologies that assist farmers to move from previous practices to more climate-smart ones, it may not be said to be altogether new. It is largely another contemporary sustainable agricultural measure, which however focuses extra attention on climate change effects. It relates more with adapting what already exists in a local area to the climate change effects peculiar to that area. Khatri-Chhetri et al. (2019) argued that CSA approach is evolving as a new way of adapting agriculture to the changing climate around us. It builds on existing efforts to actualize sustainable agriculture intensification such as Sustainable Crop Production Intensification (SCPI) (FAO 2012).

According to the definition of CSA, any practice or mix of practices that achieves all or some of the three CSA objectives is climate-smart. In this light, Campbell et al. (2014) opined, that CSA practices include land and water management techniques, which have potentials to build capacities to recover from stress against climate change, improve productivity, and reduce greenhouse gas (GHG) emissions per unit of output. One main example of sustainable practices that achieves almost or all CSA objectives is conservation agriculture (CA). In fact, due to its triple-win effect, CA has been acknowledged in the literature as a main example of CSA practices (Kimaro et al. 2016; Hellin and Fisher 2019; Loboguerrero et al. 2019; Rosenstock et al. 2019; Kamara et al. 2019). In some other cases, CA is equated as CSA (Gerber et al. 2013).

Based on the view of Cambell et al. (2014), soil conservation being a process of maintenance or combination of processes to improve soil quality/ fertility (Johnston County Government [JCG] 2013), is climate-smart. In support, Osiru (Undated), a professor of agronomy and physiology, in a report on scoping CSA in Uganda, classified soil conservation practices as an example of CSA. Examples of such CSA practices used in marginal areas in Uganda were: terracing, strip and contour cultivation, ridge and tie ridging practices (Osiru, Undated).

In a review of several literatures, Anuga et al. (2019) presented a long list of CSA practices, such as afforestation; minimum/zero tillage; organic/green manuring; composting; tillage management; organic fertilizers derived from animal matter, human excreta or vegetable matter. Others include rainwater harvesting; mulching; on-farm water management; pro-water conservation behaviours; use of information communication technologies (ICT), especially for weather information (Anuga et al. 2019). Apart from practices like the use of mobile phones and radio/television, all other practices are practices recognized under the different types of soil conservation practices known today. In other words, the adoption of soil conservation practices is also an adoption of climate-smart agriculture.

CSA Practices and Income

According to FAO (2018a), over three-quarters of global poor resides in rural areas, and majority of them live on agriculture. Agriculture, due to its very high vulnerability to climate change effects suffers the most if effects from climate change are not mitigated. For example, between 2006 and 2016, in developing countries, agriculture bore the burden of 26 percent of total damage and loss created by disasters due to climate (FAO 2017, 2018b). Without necessary action on climate change, as in CSA, climate change effects will disrupt the livelihoods of millions of rural farmers whose source of incomes is agriculture (FAO 2018b). Climate change impacts income indirectly by reducing farm yield.

Based on the climate change impact model results presented by the Financial and Fiscal Commission (FFC), Republic of South Africa (2015), crop yields suffer the most from effects due to climate change. Schulze (2016) therefore warned that climate change impacts productivity of farming operations, as well as creating risk associated with interruptions in production, with consequences for food security and income for millions of households who depend on agriculture in South Africa. It was highlighted further that inaction will not only affect rural people alone, but even urban population, by exposing all groups to higher and more unpredictable food prices (FAO 2018b). In an attempt to stress the relevance of income amongst all benefits resulting from the adoption of CSA option, the first CSA objective is to achieve increased productivity and income (Paustian et al. 2016; FAO 2017).

Factors Influencing Smallholder Farmers' Adoption of CSA Practices

Understanding smallholder farmers' adoption behavior and factors influencing their decision-making process relating to new technologies is key to creating policies for better adoption intervention programs. According to Khatri-Chhetri et al. (2017), several farm level studies indicated that choice for CSA option could improve crop yields, increase input use efficiency, increase net income and reduce GHG emissions. However, as it is with many other new technologies, despite the enormous merits of CSA technologies, current rate of adoption by farmers is fairly low (Palanisami et al. 2015; Mutoko et al. 2015; Khatri-Chhetri et al. 2017). Several factors therefore prevail on farmers' (especially smallholders) decision-making abilities based on the particular environment where they live.

A review of FAO (2014) analysis on factors which hinder the adoption of sustainable productive practices by smallholder farmers can be sub-divided into personal and demographic; socio-economic; physical/environmental; and institutional factors. The issue of gender was highlighted, because women farmers face specific gender barriers that further impede their innovative capacities for more sustainability (FAO

2014). Paris and Rola-Robzen (2018) lamented that gender is one of the many relevant socio-cultural dimensions normally included in climate change vulnerability assessments, but rarely included in adaptation research and planning. Anuga et al. (2019), in a paper on determinants of CSA adoption among smallholder food crop farmers in Ghana, emphasized the following factors which influence farmers to adopt CSA practices. These are socio-cultural factors of farmers like customs, beliefs and values; the economic costs and benefits associated with CSA practices; land degradation due to long periods of land use, deforestation, bush burning and over-grazing; environmental factors; farmers' personal factors, highlighting the significance of farmers' perception, values and morals regarding the environment. According to McDonald et al. (2015), farmers who perceive the environment as symbiotic partners seem more likely to use practices on-farm that create a harmony with nature, and they will be more likely to see conservation agriculture of great importance, not just for increased yields but to also provide protection for the environment.

Earlier studies by Ervin and Ervin (1982) and Asafu-Adjaye (2008) classified factors responsible for adoption of soil conservation practices as personal, physical, institutional and economic factors. They however highlighted the significance of perception of soil erosion as the precursor for farmers' motivation to adopt any conservation practice. Duvel (1991) model classified determinants of individual behavioral change as personal, physical, economic, social, cultural and communication. It was emphasized that there is another group of variables regarded as mediating or intervening variables, which mediate the effects of other independent variables. In adoption-behavior studies, there are several categories for grouping determinants of innovation adoption, there is however no clear distinctions between variables of each category; categorization is done to suit a current technology under study, the area where the study is conducted, and the investigator's view, or even to the taste and requirements of customers (Mwangi and Kariuki 2015).

Given therefore the characteristic fragile nature of farmers in Africa and their business, consisting largely of smallholders, with very little chances for commercialization, low asset base, and fairly low rate of soil conservation adoption, a paper like this is therefore very pertinent. It seeks to evaluate how smallholder farmers' adoption of CSA influences overall income of farmers, using the adoption of soil conservation practices at Qamata Irrigation Scheme, Eastern Cape, South Africa as a case study. The main hypothesis is that smallholder farmers' adoption of CSA practices has no significant influence on farmers' overall income in the study area. The expectation is that findings of this paper will add to existing literature on influences of the adoption of CSA, and assist development agenda in the promotion of CSA, both in South Africa and beyond. In order to achieve the goal of this paper, the following specific objectives are itemized.

Specific Objectives

1. To assess smallholder farmers' awareness and perception on extension recommendations for soil conservation in the study area;
2. To identify soil conservation practices available in the study area; and
3. To evaluate the influence of CSA adoption on smallholder farmers' overall income, using the case of soil conservation practices at Qamata Irrigation Scheme, South Africa.

Against this background, the following construct was used to breakdown the problem of this paper into manageable bits for the required information needs.

Problem Conceptualization

According to Duvel (1991), individual behaviors are determined by independent variables. Such variables include demographic, socioeconomic, institutional and physical factors. However, the effect of independent variables is mediated by a group of three other variables called mediating variables. These variables are needs, knowledge and perception. But due to the relevance of farmers' perception in practice-adoption, as argued in the literature (Ervin and Ervin 1982; Asafu-Adjaye 2008; Ighodaro 2016; Ighodaro and Mushunje 2017), this paper believes that smallholder farmers' perception of soil conservation practices recommended by extension in the study area is key if farmers will adopt the practices recommended for soil conservation in their area.

Based on this, a simple problem conceptualization used for the information needs of this paper states thus. Smallholder farmers' decision-making behaviour regarding soil conservation is influenced by their various independent factors, being mediated by their perception on soil conservaion practices. Smallholder decision-making behavior regarding soil conservation is influenced by their various independent factors, being mediated by their perception on soil conservation practices recommended by extension officers in their area. The outcome of their behavior is expressed in the form of various benefits such as improvement in livelihoods, farm productivity and incomes.

METHODOLOGY

Study Area

This study was conducted in an irrigation scheme, called Qamata Irrigation Scheme, located in Qamata community, Intsika-Yethu local municipality, Eastern Cape, South Africa. Qamata is a small town located on latitude 31°58'39"S and longitude 27°26'2"E, with an altitude 867m. Qamata Irrigation Scheme, as a scheme was established in 1960, but only took effect in 1972. It was established to address the hunger and food insecurity situation of Qamata and the surrounding communities, focusing mainly on the cultivation of crops, even though farmers rear livestock on their own at home.

Data Collection and Analyses

In compliance with the South African Department of Higher Education and Training (DHET) policy on research studies in South Africa, an ethical clearance was obtained from the University of Fort Hare Ethics Clearance Committee on the 24th of July, 2014, with Certificate Reference Number: MUS0111SIGH01. Adopting the case study research design approach, 70 smallholder farmers were selected in a group interview session, with the aid of a pre-tested structured questionnaires (with open and closed-ended questions). With the assistance of the extension officer managing the scheme, farmers were organized in groups to aid the interview sessions. Though several information were provided by farmers, but for the purpose of this paper, basic information include: personal and demographic characteristics; perception on soil conservation from extension, and information on incomes (from agriculture and non-agricultural sources).

Data collected were analyzed using the SPSS version 25. Specific data analyses processes include basic descriptive statistics like frequency, percentage and mean. Empirical data were modelled using the multiple linear regression analysis process. Although other regression models may have been considered for this analysis, the multiple linear regression was chosen because the dependent variable (farmers' overall income) was a continuous variable. As a predictor model, the multiple linear regression model was used to determine how the adoption of CSA, using the example of soil conservation practices, influence smallholder farmers' overall income at Qamata Irrigation Scheme. Annor-Frempong and Duvel (2011) argued that descriptive statistics are necessary first steps required to ascertain the distribution and summary of large variables before tests of relationships can be implemented, using other higher testing techniques like multiple regression.

Model Specification: Multiple (Linear) Regression Analysis

The multiple regression analysis models are used to predict the values of variables (dependent variables) based on the values of two or more other variables (called independent or explanatory variables) (Laerd Statistics 2018). Multiple regression analysis usually takes the form specified below:

$$y=\alpha + \beta x + \varepsilon \bullet \qquad (1)$$

Where, y = Overall income of smallholder farmers

x = Exogenous input data of smallholder farmers' soil conservation (CSA) adoption in the study area

α = Intercept of y

β = Partial regression coefficient (Parameters to be estimated)

ε= Stochastic error term

Therefore, the regression equation for the study area is specified as follows:

$y = \beta 1AGE + \beta 2HHEAD + \beta 3FARMS + \beta 4FARMT + \alpha\beta 5AWARE + \beta 6OWNEXT + \beta 7PERCEXT$ …………………………………………(2)

Description of Variables Used in the Paper

Based on this paper, Table 1 is a concise presentation of all variables used in the multiple linear regression model. Whereas the dependent variable consists of farmers' overall (total) income, seven input variables were carefully selected in relation to the objectives to explain the variance in the dependent variable.

RESULTS

Demographic Characteristics of Farmers in the Study Area

According to Table 2, majority of farmers in the study area are old (60%), with only 3 percent exceeding Grade 12. The suggestion is that the study area consisted of ageing farming population with relatively low levels of education, which is not a positive sign for technology adoption. Income variables (farm and off-farm incomes), as reflected in Table 2, show that most of the

Table 1: Variable description, measurement and a priori expectations

Variables	*Description*	*Unit of measurement*		*A priori expectation*
Y	*Dependent Independent*	*Total income of farmers*	*Rand*	
X1	AGE	Age of farmers	Years	+/-
X2	HHEAD	Household head	1= Father; 2= Mother; 3= Children	+/-
X3	FARMSIZE	Farm size	Hectares	+
X4	FARMTYPE	Type of farming practiced	1= Smallholder; 2= Commercial; 3= Others	+/-
X5	AWARE	Awareness of soil conservation introduced by extension	1= Yes; 2= No	+
X6	OWNEXT	Preference for own soil conservation practice instead of extension recommendations	1= Yes; 2= No	+
X7	PERCEXT	Perception on recommended practices by extension	1= Ineffective; 2= A little effective; 3= Moderately effective; 4= Effective; 5= Very effective	+

Table 2: Farmers' characteristics in the study area

Farmers' characteristics	*Statistics*	*Farmers' characteristics*	*Statistics*
Average age	60 yrs	Off-farm income (Years)	>R20000 (67%)
Education	None (20%)		Others (33%)
	Grade 1-12 (77%)	Overall income/year	≥R30, 000 (66%)
	Diploma (3%)		>R30, 000 (34%)
Gender	Male (60%)	Average household size	4 members
	Female (40%)	Farming experience	<18yrs (50%)
Marital status	Married (74%)		≥18yrs (50%)
	Others (26%)	Household head	Father (67.1%)
Marital status	Married (74%)		Mother (31.4%)
	Others (26%)		Children (1.4%)
Marital status	Married (74%)	Farm size	1-2ha (70%)
	Others (26%)		>2ha (30%)
Farm income (Years)	R1000-R10000 (78%)	Farming on one spot	≤10yrs (38%)
	Others (22%)		>10yrs (62%)

Source: Survey research, 2014

farmers obtain a larger percentage (67%) of their incomes from off-farm activities, indicating the subsistent nature of farming in the study area. In other words, farming is not a major income source for farmers in the area. Similarly, 66 percent of farmers' population have a yearly overall income of R30000, which is an equivalent of about R2500 monthly income, reflecting the level of poverty in the area. Two thousand five hundred rand (R2500) is relatively too small compared to the current high standard of living in South Africa, and still below the current national minimum wage of R3500 (The Presidency, Republic of South Africa 2018).

More so, the gender ratio of male to female farmers in the study area was 3:2 (see Table 2), indicating a gender bias in the area. This is quite different from literature evidence, which suggests that women contribute more to agricultural production in most developing countries, especially in sub-Saharan Africa (Paris and Rola-Rubzen 2018). Farmers' experience in farming was found to be relatively large, because half of them have been involved in farming for over 18 years at the time of interview, which is somewhat positive for technology adoption decision making. Experience, as generally known, is one key factor for business success. The study area also consisted of more male-headed households (67%), which also is positive for technology adoption, especially in this part of the world where societal benefits seem to favor men than women. Similarly, farm sizes show that 70 percent of farmers have between 1-2ha of farmland, which was an indication of the type of farming prevalent in the area: smallholder/ subsistent farming. This however is typical of a smallholder farm in sub-Saharan Africa: small farm size, usually less than five hectares, producing largely for household consumption, labor consist largely of family members, and capital is usually inadequate. Further, a large proportion (62%) of farmers have been farming on one spot (piece of land) for over 10 years, which is significant enough for the manifestation of signs of soil degradation. In most cases, evidences of soil degradation usually serve as motivation to farmers' adoption of appropriate soil conservation measures.

Farmers' Awareness and Perception on Soil Conservation Practices in Study Area

According to further findings (see Table 3), a larger percentage (86%) of farmers indicated awareness of soil conservation practices encouraged by extension officers in their area. Usually, awareness is a main prerequisite for technology adoption. Variables on the perception of smallholder farmers on recommended practices by extension, indicated that virtually every farmer had one good thing or the other to say about such recommendations. The suggestion is that farmers' perception is positive regarding practices introduced by extension, which is positive for adoption of technologies.

Table 3: Farmers' awareness and perception on soil conservation practices

Awareness of Recommended Soil Practice	
Yes	86%
No	14%
View on Recommended Soil Practice	
Good	48%
Effective	17%
Very effective	1%
I can recommend and train others to use it	11%
It preserves our land	10%
Others	11%

Source: Survey research, 2014

Soil Conservation Practices in the Study Area-Traditional and Extension-Recommended

In terms of soil conservation practices and extension recommendations found in the study area, findings (see Table 4) indicate that virtual-

Table 4: Conservation Practices in the study area

General practices	*Frequency*	*Percent*
Crop rotation	17	24
Mixed cropping	3	4
Contour ploughing	6	9
Plant cover	3	4
Use of fertilizer/ manure	11	16
Avoid overgrazing	5	7
Fallowing	4	6
Conservation tillage	3	4
Others	18	26
Extension recommendations	*Frequency*	*Percent*
Crop rotation	25	36
Conservation tillage	14	20
Others	31	44

Source: Survey research, 2014

ly all recommendations by extension officers were practices already available in the area; farmers may have known them with different names. Over time, extension officers have worked with farmers in the study area and introduced various soil management practices. There was a bit of challenge for some farmers to differentiate between extension recommendations and their own traditional practices for soil conservation.

Influence of Soil Conservation Practice Adoption on Farmers' Overall Income

Table 5 represents a correlation matrix of independent variables of this paper. Based on findings, apart from the relationships of farming type (FARMTYPE) and farmers' perception on extension recommendations (PERCEXT) (-.275), and that of AGE and household head (HHEAD) (.267) which both correlated fairly, virtually all the other coefficients are below 0.2, which indicates there is no serious problem of multi-collinearity. The suggestion of FARMTYPE and PERCEXT is that smallholder farmers have a negative perception of extension recommended practices in the study area. This may not be unexpected because, majority of farmers in the study area are old, and old people are known to be conservative and risk averse with respect to new ideas or ideas different from what they are used to. Also, the case of AGE and HHEAD suggests that older farmers are from male-headed homes, which agrees with the descriptive data, that indicate that majority of farmers in the area are males heading their homes.

According to Table 6, four out of all variables tested in the paper model were useful in providing explanations for the variance in overall income of smallholder farmers (dependent variable) as stipulated by this paper. The four variables are age of farmers (AGE); household head (HHEAD); awareness of soil conservation practice promoted by extension (AWARE); and farmers' perception on recommended practices

Table 5: Correlation matrix of CSA and overall incomes variables in the study area

Variables	*PERCEXT*	*OWNEXT*	*HHEAD*	*FARMSIZE*	*AWARE*	*AGE*	*FARMTYPE*
PERCEXT	1.000						
OWNEXT	-.001	1.000					
HHEAD	.136	-.005	1.000				
FARMSIZE	.011	.060	.025	1.000			
AWARE	-.003	.064	-.091	-.076	1.000		
AGE	.149	-.056	.267	-.032	.096	1.000	
FARMTYPE	-.275	-.075	-.206	.008	-.044	-.102	1.000

Table 6: Regression coefficients of CSA and farmers' overall income in the study area

	Unstandardized Coefficients		*Standardized*	*T*	*Sig.*	*Collinearity Statistics*	
Variables	*B*	*Std. Error*	*Beta*			*Tolerance*	*VIF*
Constant	-7433.427	9919.522		-.749	.456		
AGE	2965.239	1485.489	.225	1.996	.050**	.896	1.116
HHEAD	-4865.256	2481.414	-.223	-1.961	.054**	.878	1.139
FARMSIZE	2507.097	1330.744	.202	1.884	.064	.989	1.011
FARMTYPE	5223.979	2937.038	.201	1.779	.080	.886	1.129
AWARE	6691.783	3411.923	.213	1.961	.054**	.963	1.039
OWNEXT	4048.206	2400.275	.181	1.687	.097	.982	1.019
PERCEXT	-1338.936	665.458	-.225	-2.012	.049**	.906	1.104
R^2	.296						
Adjusted R^2	.216						
Overall Sig.	.002						
Durbin-Watson	2.097						
F	3.716						

Note: *= 10%; **= 5%; and ***= 1% levels of significance by extension (PERCEXT). While AGE and AWARE were both positively significant in influencing overall income, HHEAD and PERCEXT were both negatively significant. The adjusted R^2 and R^2 statistics of the model were .216 and .296. Findings show that our regression explains 30 percent of the variance in our data. The Durbin-Watson d was equal to 2.097, which is in-between the two critical values of $1.5 < d < 2.5$. The assumption therefore is that there is no first order linear auto-correlation in our regression data. More so, finding of our regression F test which has the null hypothesis that our model explains a zero variance in the dependent variable (that is $R^2 = 0$), indicates that the F-test is highly significant (.002). It is therefore assumed that our model explains a significant amount of the variance in the overall income of smallholder farmers in the study area. Further, the absence of serious multi-collinearity was confirmed as tolerance level in our model was over 0.1 and VIF was less than 10.

DISCUSSION

As it is well acknowledged today, without necessary action on climate change, climate change effects will disrupt the livelihoods of millions of rural farmers whose source of incomes is agriculture (FAO 2018b). CSA technology therefore is an evolving strategy to combat climate change effects. It has been defined as any farm practice or group of practices that aim to improve farmers' productivity and income, strengthen farmers' resilience against climate change, and reduce or possibly eliminate greenhouse gas (GHG) emissions from the atmosphere (FAO 2017; Paustian et al. 2016). In this regard, soil conservation practices, being practices that aim to improve soil quality, farm yield and productivity, which eventually achieve CSA goals, was regarded as climate smart. This paper was designed to evaluate how the adoption of CSA practices influences smallholder farmers' overall income, using the case of soil conservation practice adoption at Qamata Irrigation Scheme, Eastern Cape Province of South Africa. The main hypothesis was that there is no significant relationship between smallholder farmers' adoption decisions regarding soil conservation practices promoted by extension officers in the study area and their overall income. In other to achieve this, three specific objectives were put forth: (1) to assess smallholder farmers' awareness and perception on extension recommendations for soil conservation in the study area; (2) to identify soil conservation practices available in the study area; and (3) to evaluate the influence of CSA adoption on smallholder farmers' overall income, using the case of soil conservation practices in the study area. Discussion of findings therefore is tailored according to these objectives as follows.

Farmers' Awareness and Perception on Soil Conservation Practices in the Study Area

Based on findings, a larger percentage (86%) of farmers indicated awareness of soil conservation practices encouraged by extension officers in their area, which is a positive factor for adoption due to the role awareness plays in technology adoption. According to Agidew and Singh (2019), adoption process of any technology begins first with awareness of the technology and ends with final usage of the technology. Concurring, Alemu et al. (2019) emphasized that farmers' awareness of soil erosion is invariably a major factor that motivates willingness to adopt soil conservation. With particular focus on climate change adaptation, Akano et al. (2018) maintained that the level of farmers' awareness can considerably influence capacity of farmers to adapt to climate change. In terms of farmers' perception on recommended practices by extension, findings indicated that virtually every farmer had one good thing or the other to say about such recommendations. The suggestion is that farmers' perception is positive regarding practices introduced by extension. Positive perception usually aids adoption of new technologies (Ighodaro and Mushunje 2017). In Ethiopia for example, among many reasons given for failure of adoption of soil and water conservation (SWC) technology intervention was a lack of farmers' perception of soil erosion. However, adoption of technologies is not always straight forward. Several other factors, both external and internal, prevail on farmers per time, ultimately resulting to the type of adoption behavior portrayed.

Soil Conservation Practices in the Study Area-Traditional and Extension-Recommended

In terms of soil conservation practices and extension recommendations found in the study area, our findings indicate that virtually all recommendations by extension officers were practices already available in the area, even though farmers may have known them with different names. There was a bit of challenge for some farmers to differentiate between extension recommendations and their own traditional practices for soil conservation. Current finding supports the view that CSA is not altogether new. For instance, FAO (2012) maintained that CSA builds on existing efforts to actualize sustainable agriculture intensification such as Sustainable Crop Production Intensification (SCPI). According to the findings of this study (see Table 5), two main practices currently being emphasized by extension in the study area are crop rotation and conservation tillage, which also are two main pillars of conservation agriculture (CA), a key example of CSA. In the literature (see Kimaro et al. 2016; Hellin and Fisher 2019; Loboguerrero et al. 2019; Rosenstock et al. 2019; Kamara et al. 2019), CA has been acknowledged as a main example of CSA practices, and even equated with CSA (Gerber et al. 2013), in other instances.

Influence of Soil Conservation Practice Adoption on Farmers' Overall Income

Based on empirical results (see Table 5), farm type (FARMTYPE) correlated fairly with farmers' perception on soil conservation practices recommended by extension officers (PERCEXT). The indication is that smallholder farmers have a negative perception of extension recommended practices in the study area. This may not be unexpected because, majority of farmers, as descriptive statistics (see Table 2) indicated, in the study area were old. Old people generally are known to be conservative and risk averse with respect to new ideas or ideas different from what they are used to. Also, age of farmers (AGE) and household head (HHEAD) correlated fairly, suggesting that older farmers are from male-headed homes, which agrees with the descriptive data, that indicated that majority of farmers in the study area are males heading their homes.

At 5 percent level of significance (see Table 6), AGE and AWARE were both positively significant in influencing smallholder farmers' overall income, while HHEAD and PERCEXT were both negatively significant in influence. The suggestion is that older farmers are more likely to have increases in their overall income in the study area as a result of their adoption of soil conservation practices. This was partially expected, because age as a variable in technology adoption is dual in impact. Brown et al. (2019) posited that the relationship between age and technology adoption is empirically ambiguous. For example, Brown et al. (2016) and Brown et al. (2019) both found that younger people are more willing to explore and adopt new technologies (thus experiencing the gains of adoption such as increase in income). On the other hand, Agidew and Singh (2019) found in their study that older people are more likely to adopt sustainable land management (SLM) practices, thereby experiencing the benefits thereof, which is consistent with the finding of this paper. The result of this paper is also consistent with Biratu and Asmamaw (2016), who found that, among all those who participated in soil and water conservation (SWC) activities in Ethiopia, older farmers participated better with full interest. It also confirms findings by Mwangi and Kariuki (2015) and Abebaw and Haile (2013), who both find that older farmers are more willing to adopt joining farmers' group than younger farmers, thus accessing the associated benefits.

Similarly, farmers' awareness of extension recommendations (AWARE) was positively related with farmers' overall income. The suggestion is that, farmers who are aware of extension recommendations for soil conservation have more probability for increases in their overall income as a result of soil conservation adoption in the study area, which was expected. According to Agidew and Singh (2019), awareness of innovation is usually the first step in the adoption process. Findings of this paper is thus consistent with that by Agidew and Singh (2019), who found that one of the reasons why sustainable land management (SLM) practices was not adopted in Ethiopia was lack of awareness of the technology. Similarly, finding here is congruent with Anseera and Alex (2019), who found that farmers' level of awareness was a main factor that influenced the extent climate resilient practices were adopted in Kerala State.

Moreover, household head (HHEAD) was negatively significant in influencing smallholder farmers' total income, which was unexpected.

The suggestion is that female-headed households have more potentials for increased overall income in the study area as a result of the adoption of soil conservation. This may be particularly true in areas where practices being promoted by extension are not too difficult to apply or require too much man-power. Also it may be true in areas where females have unbiased and unrestricted access to land and other farming resources, as well in areas where there are more women in farming. In the view of Twyman et al. (2014), in East Africa, women are less likely than men to be aware of CSA practices, but when they are aware, they are just as likely as men, if not more so, to adopt CSA practices. Findings of this paper is consistent with that in Malawi where woodlots, a type of agroforestry, was promoted as source of fuelwood. Toth et al. (2019) found that communal woodlots were adopted in areas where there are more female-headed households, unlike areas where there are more male-headed households. Findings of this paper is however inconsistent with findings by Alemu et al. (2019) in Ethiopia regarding the adoption of soil conservation technologies, who found that unlike their female counterparts, majority of male-headed households in the area were more willing to participate in soil water conservation (SWC) activities.

According to literature evidences (Alemu et al. 2019; Bopp et al. 2019), perception plays highly significant roles in technology adoption processes. However, findings of this paper proved otherwise, as farmers' perception regarding extension recommendations for soil conservation (PERCEXT) was significantly negative in association with overall income of smallholder farmers in the study area. The suggestion is that farmers who hold a negative perception of extension recommendations have more likelihood for increased overall income as a result of the adoption of soil conservation, which was unexpected. Findings of this paper is similar to that of Agidew and Singh (2019) in Northeastern Highlands of Ethiopia. According to them, contrary to expectations, the regression result for farmers' perception regarding the profitability of sustainable land management (SLM) practices was also negatively significant at 1 percent.

However, negative perception as discovered in this paper may not necessarily be out-right negativity. It may relate firstly to issues such as farmers rating their own practices better than that of extension. In Namibia, for example, Selato (2017) and Jiri et al. (2016) said that the non-adoption of seasonal climate forecast (SCF), a scientific forecast of weather, was sometimes due to the problem where farmers favored their traditional knowledge of weather over the scientific forecasts. Secondly, it could be that of farmers' trying to protect their own practices due to tradition, culture and even religion. According to Davies et al. (2019), religious faith has shown to be a limitation to farmers accepting scientific climate information. Thirdly, it could be, perhaps that of extension not being convincing enough in communicating the new technology, or the risk averse behaviors of farmers due to uncertainties they may perceive/believe about a certain new technology. A renowned technology researcher, Rogers (2003) listed five innovation characteristics that influence innovation adoption. These are: relative advantages; compatibility; complexity; triability; and how visible outcomes of the technology is on other farmers. To however emphasize the overarching role of perception in adoption processes, Hoffmann et al. (2009) maintained that for innovation factors as indicated by Rogers to correctly influence decision-making process, it is rather a function of how such innovations are subjectively perceived by individual farmers. As indicated, there are enough evidences that relate positive perception with improved adoption and the associated benefits. In this respect, Duvel (1991) and Rogers (2003) argued that farmers who view/perceive an incoming technology of low prominence than theirs usually shy away from adoption, and as such would be unable to access benefits associated with adoption.

CONCLUSION

While Africa is predicted to suffer most from effects of ever-growing changes in climate and weather variabilities, agriculture is the most sector to bear the brunt, and smallholder farmers' income is already under great threats. CSA technologies, a sustainable agricultural measure is being progressively promoted and adopted globally to address problems due to climate change and weather variability. In this regard, this paper was designed to evaluate the influence the adoption of CSA practices has over smallholder farmers' overall income, using the case of soil conservation practice adoption at Qamata Irrigation Scheme, South Africa. Based on findings, majority of farmers in the study area are aware and hold positive perception of recommended soil conservation practices by extension in their area. Similarly, two most recommended soil conservation practices by extension officers in the study area are crop rotation and conservation tillage. According to empirical results, farmers' age and awareness of soil conservation practices recommended by extension were both positively and significantly related with overall income of farmers. On the other hand, household head and farmers' perception regarding recommended practices by extension were both significantly negative. It is therefore concluded that the adoption of CSA/soil conservation practices by smallholder farmers at Qamata Irrigation Scheme has significant influence on farmers' overall income in the study area. The indication is that farmers who employ CSA practices are financially empowered for improved food security and overall livelihood, which also enhances national food security and income.

RECOMMENDATIONS

It is therefore recommended that all significant factors of this paper should be given due consideration when designing programs for the adoption of CSA/soil conservation practices in the study area and beyond. Specifically, adoption potentials of older farmers in the study area should be strengthened greatly. This can be through the provision of regular up-to-date agricultural technology and marketing information for farmers' right where they are, since old people are slower to access such information, or ensuring that a more versatile extension officer is provided for the irrigation scheme and for farmers. Also, factors which cause youth to migrate to cities in search of 'so-called' greener pastures, or to see agriculture as a job for old people or less lucrative profession in the study area should be addressed. Examples of such factors are the provision of adequate basic infrastructures such as good roads, good schools (secondary and tertiary), good housing facilities, internet services, et-cetera. Women farmers should be encouraged to access all agricultural inputs as their male counterparts, because they are usually the least encouraged in many sub-Saharan countries. Finally, all factors that limit smallholder farmers' perception of soil conservation practices should be addressed. The extension officer(s) provided at the scheme will have a great role to play in this regard. They will have to employ a mix of good communication strategies that will best convince farmers on CSA technologies, so they can be viewed and held with high prominence.

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