Assessing Household Socio - Economic Factors Affecting Smallholder Farmer's Investments in Climate Smart Agriculture Practices in Eastern Cape Province, South Africa.

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Abstracts

Climate change would likely pose significant challenges to agricultural productivity. Such adverse climate change effects may result in greater crop pests, loss of soil moisture content, rapid soil nutrient depletion, and a substantial decrease in crop productivity and yields. Climate-Smart Agriculture (CSA) is one solution that simultaneously addresses the issues of climate change and agricultural productivity. Inadequate attention has been paid to socio-economic factors affecting smallholder farmers' investments in climate-smart agriculture in rural communities and the adaptive capacity of the smallholder farmers. The present study aimed to assess the socio-economic factors affecting smallholder farmers' investments in climate-smart agriculture in the Eastern Cape Province of South Africa. The study used a mixed method design combining qualitative and quantitative approaches. A sample of two hundred farmers was selected for the study. Findings revealed that inadequate credit facilities, high cost of farm inputs, and limited knowledge of CSA practices were the major barriers to investments in CSA technologies among smallholder farmers. The results from Ordinary Least Square Regression indicate that the Number of years in school, farming experience, access to credit, climate change information, and access to extension services significantly affect smallholder farmers' investments in CSA. The study concludes that for a successful transition to CSA in rural communities' governments need to consider indigenous knowledge system-based climate change support and interventions to empower farmers with the capacity to withstand climate change challenges.

Keywords: Climate smart agriculture, Smallholder farmers, Climate smart agricultural finance**,** Productivity, Eastern Cape.

1. Introduction

Globally, climate change and variability significantly hinder agricultural productivity and transformation with increased experiences of unpredictable, erratic rainfall and severe temperature threatening food security and rural livelihoods [1]. Agriculture remains the mainstay of most economies [2,3]. In particular, the smallholder agricultural system in the SSA region has been identified as one of the world's economic subsectors that are most at risk of climate change because it depends heavily on natural resources and rain-fed agriculture [4]. The realities of climate change call for quick action by smallholder farmers to combat the potential detrimental impacts on food production, food security, the environment, resilience, sustainability, and livelihoods.

The transformation of agri-food systems is crucial to meeting the Sustainable Development Goals (SDGs). With nearly 690 million people around the world facing hunger today [5]. Agri-food systems emit one-third of global anthropogenic GHG emissions [6]. With a growing public demand for climate action, it is pressing to achieve food security while adapting to - and mitigating – climate change. Climate-smart agriculture (CSA) has grown from a concept into an approach implemented throughout the world by all types of stakeholders. Climate change adaptation research in agriculture has identified climate-smart agriculture (CSA) as one of the many sustainable agricultural practices (SAPs) that can make households withstand the harmful effects of climate change and variability in smallholder farming systems [7]. Hundreds of technologies, practices, and approaches fall under the heading of CSA. Such critical practices and techniques include crop diversification intercropping, agroforestry, conservation tillage, cultivation of drought-resistant crops, water harvesting, and integrated soil fertility management, among others [8]. To improve resilience and to enhance agricultural production and rural livelihoods, systematic response to climate change through investments in CSA practices and technologies is still very limited in South Africa and Eastern Cape province for a host of reasons. Investment in CSA is meager among smallholder farmers. In view of this, this study aims to assess household socio-economic factors affecting smallholder farmers' investment in CSA practices and identifies CSA practices commonly used in the Eastern Cape Province of South Africa.

Literature Review

Determinants of CSA investments among smallholder farmers

Climate-smart policies have also been shown to improve decision-making, enhance resilience and adaptive capacity to change agro-climate conditions, and adopt feasible technologies and post-harvest practices at the farm level [9]. These policies have proved effective in managing climate risk and potentially mitigating the effects of climate change leading to a reduction in poverty, increased food security, and reduced economic vulnerability [10,11]. Several studies have tried to uncover the drivers of investments in CSA practices and their impact on household livelihood using a variety of approaches at the household level. Using Principal Component Analysis, Collins- Sowah (2018) [12] found that adoption of CSA practices in Kenya was influenced by gender, farm size, and value of productive assets, with the impact of CSA adoption being more significant in households that adopted more CSA practices. While in Southern Africa, Wekesa *et al.* (2018) [13] noted that multiple adoptions of innovations are influenced by access to credit, income, information, education level, and household size.

In contrast, assessing the impact of the adoption of CSA practices on multidimensional poverty, Makate, *et al. (*2019) [14] found a significantly higher impact in several deprived households. Adopting CSA practices was found to be through increased income or consumption via the non-food expenditure pathway. An assessment of the effect of CSA practices on livelihood outcomes by Habtewold, (2021),[15] using matching methods and simultaneous equations revealed that adopting multiple stress-tolerant crops improves household income which in turn enhances household asset accumulation. They also found that adopting improved livestock breeds significantly reduces household income and attributed this to the possibility of income being invested in livestock rather than household assets as a more resilient measure than investment in domestic household assets.

It is noted that CSA is not a one-size-fits-all practice or one strategy but an array of practices integrated into an agricultural system at various scales [16]. It is noted that there is no CSA blueprint and that its implementation is subjected to a country or community's specific context [17]. FAO (2010) [18] reported that CSA strategies incorporate traditional and innovative practices and technologies relevant to a location's context for the adaptation to climate change. Nagargade, *et al.* (2017) [19] stated that there are uncertainties around the practice about what technologies and practices should be categorized as CSA and which of the three pillars (productivity, adaptation, and mitigation) should be given priority in any given context

Malefiya (2017) [20], established that different climate innovative agricultural practices are adopted by various farmers, which enhance the farmer's response to climate change. However, investment in climate-smart agricultural practice is influenced by the farmers' socio-economic, demographic, and institutional characteristics. Demographic characteristics such as age, household size, sex, and educational level of household; socio-economic characteristics such as land and household income affect farmers' decision to invest in climate-smart agricultural practices. Institutional factors affecting farmers' decision to invest in climate-smart agricultural training include the availability of credit, access to agricultural extension agents, and information on climate change. Nyanga *et al*. (2016) [21] argue that people with permanent tenure tend to invest in long-term conservation practices. The availability of CSA technologies, farmer-based insurance opportunities, access to labour, and increased incidence of weeds and pest occurrence can reinforce environmental and economic determinants of CSA investments [22,23]. High costs associated with CSA technologies can also hinder farmers, especially smallholders primarily associated with low levels of income [24,25]. In some instances, the technologies are unavailable at the local level, limiting farmers' ability to access them. Farmers' perception of CSA is an influencing factor in the investments in CSA practices. Individual farmers consider the benefits of CSA, especially with regard to productivity, before venturing into this form of agriculture [26,27]. According to Green *et al*. (2014),[28] farmers who hold the view that CSA has the potential to enhance productivity positively are more likely to invest than those who do not. Mayaya *et al*. (2015) [29] mentioned inadequate resources, weak technical and institutional capacity, and the cost of adoption of technologies as the main barriers to smallholder household adaptation. In addition, they also mentioned the high cost of farm inputs, delays in meteorological information, lack of subsidies, inadequate credit facilities, poor access to agricultural extension services, agricultural markets, limited farm size, and inadequate labour as the barriers to CSA practices.

2. Methodology

The study employed a quantitative and qualitative approach to identify the CSA practices in the farming system and the household socio-economic factors affecting smallholder farmers' investment in the study area. The study specifically applied a cross-sectional design based on which the sample was selected, and the data collection was conducted.

3.1 Study Area

The study was conducted in Eastern Cape Province, the second largest Province in South Africa after Northern Cape Province, with an area of 169 580 km², representing 13.9% of South Africa's total landmass [30]. The study was conducted in the Amathole district municipality.

Source: [31] ECDC, 2013

Figure 3.1: Map showing Amatole District Municipality of the Eastern Cape Province

3.2 Agricultural potential of Amatole District Municipality

Farming practice in Amatole District Municipality is very high but limited by the availability of arable land due to steep slopes and hilly areas surrounding the Amatole areas with altitudes ranging from 550 m-1 680 m with fertile soils [32]. Some areas of Amatole District Municipality have a high potential for agricultural production. The agricultural sector contributes only 17% of the municipality's GDP [33]. However, there are various rural activities, including citrus farming, beef, and dairy products, such as the Fort Hare Dairy Trust and Middledrift Dairy project. Agriculture in Kat River Valley is supported by natural assets such as favorable soils and adequate water supply. The Kat River Valley is the primary source of water to perform agricultural activities.

3.3 Climate and Topography

Agriculture activities are also facilitated by the terraced basin topography and foot slope bottomlands enclosed by the steep mountain slopes [34]. Rainfall on the high ground is around 1000 mm per annum, whereas it is much lower in the valley bottom (600 mm), where it can only support limited rain-fed cultivation. Approximately 75% of the mean annual precipitation is received between October/November and February/March, with the highest rainfall figures recorded in March. The temperatures range from moderately hot summers to cool, moderate winters [32]. Due to unpredictable climatic conditions compounded by poor grazing practices, the area had experienced land degradation in sheet, gulley, and donga erosion on the foot slope areas [35].

3.4 Sampling Procedure and Sample Size

Respondents were selected based on participation in agricultural activities purposively. Their willingness to participate in the research was also highly prioritized in selecting respondents. The sample size was 200 smallholder farmers. The 200 smallholder farmers consist of crop farmers, livestock farmers, and farmers practicing both. A total of 12 villages were visited, and, in those villages, a specific number of farmers were interviewed. Towns within the district municipality were selected purposefully in consultation with local district agricultural offices to ensure the objectivity of survey teams. Within the village, households were selected randomly from all villages within the sampled area.

3.5 Data Collection and Analysis

To collect the data, different data collection instruments were used. Primary and secondary data were collected. Primary data focused on demographic and socio-economic factors. Secondary data were collected from the respective district agricultural office, district information desk, district head office, journals, books, records, and published and unpublished documents. Following the data collection process, data were transferred into a spreadsheet for coding to put in the appropriate format for analysis using the Statistical Package for Social Sciences (SPSS). OLS regression approach was applied to assess household socio-economic variables affecting smallholder farmers' investment in CSA practices. Descriptive statistics were applied to identify the CSA practices used mainly by smallholder farmers and the barriers facing smallholder farmers' investment in CSA practices. Descriptive statistics in the form of a 4-point **Likert scale.**

Descriptive statistics was employed with the use of climate smart adaptation strategy index.
$ASI = AS_n \times 0 + ASl \times 1 + AS_m \times 2 + AS_h \times 3$
Where,
ASI = Adaptation Strategy Index
AS_n = Frequency of farmers rating adaptation strategy as having no importance
ASl = Frequency of farmers rating adaptation strategy as having low importance
AS_m = Frequency of farmers rating adaptation strategy as having moderate importance
AS_h = Frequency of farmers rating adaptation strategy as having high importance.

The problem confrontation index (PCI) was employed to rank the barriers affecting investments in climate-smart agricultural practices in the study area. The PCI in climate change study is defined as a method or a principal factor used to assess the problem hindering smallholder farmers in adopting a particular climate adaptation or coping strategy [36,37]. The smallholder farmers ranked their perceived barriers to climate-smart agricultural investments on a 4-point Likert scale (0, no problem; 1, low problem; 2, moderate problem; and 3, high problem) [38]. Mathematically, the PCI was evaluated as:

$$PCI = Pnx0 + p1x1 + Pmx2 + phx3$$

where Pn is the number of smallholder farmers who ranked the barrier as no problem; Pl is the number of farmers who ranked the barrier as low level; Pm is the number of smallholder farmers who ranked the barrier as moderate level; and Ph is the number of smallholder farmers who ranked the barrier as high level. The PCI has been used by many authors from previous studies, e.g., Hossain and Miah (2011) [36] and Kabir *et al*. (2019) [39], to rank perceived barriers to climate change adaptation practices.

The use of OLS regression estimation technique was used to assess the effect of household socio-economic variables on the farmer's level of investment in CSA practices. The implicit form of the regression

model used is :
$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9 + U$ ……………(1)
Where Y = Amount of money invested in adaptation practices (R)
X_1 = Age of farmer (years)
X_2 = Gender of farmer (1, if male, 0 otherwise)
X_3 = Level of education (years)
X_4 = Access to extension service
X_5 = Farming system
X_6 =Farm size (ha)

X_7=Household size (number of persons)
X_8 = Access to climate info (1 if yes, 0 otherwise)
X_9= Access to credit (1 if yes, 0 otherwise)
U = Error term.

4 Results and Discussion

The descriptive analysis result revealed that sampled households of the study area respond to change in climate stresses by using mutually inclusive CSA practices such as Planting trees, use of irrigation, improve crop varieties, annual crop rotation, Mixed farming, use of drought tolerant varieties, Use of organic manure. To identify those CSA adaptive practices which held relative importance over others an adaptation index procedure was implemented, farmers were asked to assess different adaptation practices by using the four-point rating scale.

Table 1. Ranked order of the CSA practices adopted by smallholder farmers

Adaptation strategies	High	Medium	low	No	ASI	Rank
Crop diversification	123	60	17	-	506	1
Use of irrigation	106	56	33	5	463	2
Annual crop rotation	98	47	23	30	411	3
Use of organic manure	96	37	60	7	369	4
Use of improve crop variety	86	32	17	65	339	5
Reduce number of livestock	79	20	51	50	328	6
Improve herd management	42	63	50	45	302	7
Mixed farming	57	47	36	60	301	8
Different planting dates	38	20	142	-	299	9
Drought tolerant crop	29	48	100	23	283	10
Soll conservation	18	24	158	-	260	11
Planting of trees	20	16	164	-	256	12

Source: Results from SPSS (Version 25) generated from field survey, 2021

Table1 shows various CSA practices used by the farmers in the study area. Most of the CSA practices above were targeted toward drought as the increased temperature is the most perceived element in the study area. Crop diversification was ranked first and thus most important among farmers' adaptive practices to climate change; crop diversification (mixed cropping, intercropping, and dividing farmlands into varying crops) is a common practice in the study area. Followed by irrigation; although irrigation is predominantly done in the off-season, it is increasingly being used in the event of delayed rains until the onset of the rainy period. This finding agrees with Tesfay (2021) [40], who stated that irrigation improves farmers' resilience to climate change impacts through increasing agricultural productivity and household asset accumulation. Hence, it is a crucial CSA practice employed to make up for shifts in the growing season. Annual crop rotation was ranked as the third most important CSA practice and use of organic manure ranked fourth. Planting trees was ranked as the least important. Planting of trees was mainly to provide natural shade for their livestock and crops on-farm during the extended dry periods

Table 2 Barriers to investments in climate smart agriculture

Barriers	N (p)	L (p)	M(p)	H(p)	PCI	Rank
Inadequate credit facilities	18	26	34	122	520	1
High cost of farm inputs	17	28	50	105	460	2

Inadequate extension officers	12	36	64	88	440	3
Limited knowledge of CSA practices	26	22	74	78	430	4
Limited access to weather information	15	39	68	78	424	5
Limited access to irrigation	28	41	55	76	407	6
Limited access to market information	32	45	56	67	390	7
Lack of agricultural subsidies	31	48	67	54	375	8
Limited government support with farm inputs	39	48	59	54	367	9

Source: Results from SPSS (Version 25) generated from field survey, 2021

Results from Table 2 indicate inadequate credit facilities as the highest ranked barrier to smallholder farmers' investment in CSA practices with (PCI=520). Lack of credit facilities can be a significant impediment to investing in CSA practices since the availability of credits will enable farmers to purchase the necessary inputs. Access to credit allows farmers to overcome their financial constraints associated with the production and adoption of innovations. The high cost of farm inputs was ranked next as severe problem constrained investments in CSA practices (PCI 460). The high price of inputs can limit investments and upscaling climate-smart agricultural practices among smallholder farmers. This is also associated with the unavailability of credit facilities. Abegunde et al. (2020) [41] noted that for smallholder farmers, access to credit enables users of climate-smart agricultural practices to increase their adoption of climate-smart farming practices through purchasing more technology, which was hitherto expensive to buy. Limited government support for farm inputs was also a severe problem (PCI 440). Government support to subsidize the high cost of farm inputs is equally essential. Subsidies in the form of fertilizers, chemicals, and improved seeds to farmers below market prices will encourage smallholder farmers to invest more in CSA practices, thereby overcoming the barrier. Besides, as reported in Table 2, limited access to market information, lack of agricultural subsidies, and inadequate agricultural extension staff were the least barriers reported by the respondents as the constraint to investments in CSA practices.

4.2 Socio- economic factors affecting smallholder farmers investment in CSA practices.

In assessing socio-economic variables affecting the level of investment in CSA practices, OLS regression analysis was used. Amount of money invested in adaptation practices was used as the dependent variable which was regressed against household demographic and socio-economic factors. Six variables were significant out of nine variables. Number of years in school, farming experience, access to credit, climate change information, and access to extension services were significant.

Table 3: Socio -economic factors affecting smallholder farmers investment in CSA practices

Money Adp (R)	**Coefficient.**	**Standard Error**	**Z**	**P>z**	**[95% Conf.**	**Interval]**
Age	1564056	3.076539	0.05	0.960	5.912154	6.224965
Number of years in school	10.04109	9.355235	1.07	.005***	8.412375	28.49455
Gender	-50.43569	88.54079	-0.57	0.570	-225.0849	124.2135
Farm experience	52.63945	4.49318	1.17	.034**	14.12687	3.598979
Household size	-16.82691	18.62288	-0.90	0.367	-53.56106	19.90724
Access to Credit	-3.416777	114.6935	-0.03	.011**	-222.8195	229.653
Farm Size	-32.38481	38.42787	-0.84	0.400	-108.1849	43.41525
Access to CC info	183.7288	244.728	0.75	. 045**	666.4617	299.0041

Acc to extension	69.33309	89.88305	0.77	.003***	107.9638	246.6299
Constant	833.5825	351.113	2.37	.019**	141.0022	1526.163
Note. ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level						
No Observation			=	200		
Prob > chi^2			=	0.0000***		
Pseudo R^2			=	0.0695		

Source: Results from SPSS (Version 25) generated from field survey, 2021

Table 3 indicates that the number of years in school is significant at ($p<0.01$) with positive coefficient. This suggests that years spent in school has strong impact on the farmers' decision to invest in CSA practices. This result is Similar to that of Upadhyay *et al.* (2003) [42] who stated that years spent in school have a strong influence on adoption decision of the farm households and application of innovation in their farming activities. This result show that farmers with a higher level of education can understand most of the things that are required for production thus invested in CSA practices. The high level of education is vital as it allows farmers with more information access and knowledge thereby increasing their allocative and technical efficiency.

Farming experience was significant ($p<0.05$) and had a positive relationship with money invested in CSA practices. This indicates that the more years the farmer is involved in farming, the better the chances of investing in CSA practices. The result is in line with Onyeneke, *et al*. (2018) [43], who stated that farming experience significantly increases the likelihood of adjusting agricultural production and management systems. This result suggests that involving experienced farmers in promoting CSA among smallholder farmers can substantially impact the uptake of various CSA practices and enhance the implementation of CSA-related programs. Highly skilled farmers are likely to be having more information and knowledge about the essence of investing in CSA practices.

Access to credit was significant ($p<0.05$) and had a negative relationship with money invested in CSA practices. A unit increase in credit significantly decreases the likelihood of the household's head investing in CSA practices by 3%. Access to credit enables farmers to overcome their financial constraints associated with the production and adoption of innovations. Access to credit gives the smallholder farmers the economic power to grow on a large scale, which can hinder their investment in CSA practices. In the study area, inadequate access to credit facilities restricts farmers from investing in CSA practices. The result is in line with Hall *et al.* (2009),[44] who stated that communal ownership of land could also limit the financial investment in agriculture as a result of huge uncertainties associated with the kind of land ownership

Access to climate information was positive and significant($p<0.05$). Access to information and knowledge about a certain issue increases one's outlook and forces one to react positively to the possible outcome of the situation. Having access to climate information plays a major role in improving awareness levels and investment in CSA practices. The results show that farmers who have sufficient access to climate information have a higher probability of investing in CSA practices.
Access to extension services was significant ($p<0.05$) with a positive coefficient. This implies that a unit increase of 1% in extension service access will increase smallholder farmers' investment in CSA practices. Extension services are essential in empowering farmers with farming techniques, skills, and knowledge. The results show that farmers with sufficient access to extension services have a higher probability of investing in CSA practices. This result agrees with Onyeneke *et al.* [43], who mentioned that contact with extension agents increases the likelihood of adopting CSA practices. Extension services play a considerable role in informing farmers about investment in CSA practices.

5 Conclusion and Recommendations

The study examined the household socio-economic factors affecting smallholder farmers' investments in climate smart agricultural practices. The study found that the number of years in school, farming experience, access to credit, climate change information, and access to extension services were significant determinant factors in smallholder farmers' investment in CSA practices. The results suggest that climate-smart agricultural practices can offer opportunities for smallholder farmers to address the threats posed by climate change to agricultural activities. The results further indicate that crop diversification, use of irrigation, crop rotation, and use of organic manure were mainly used as CSA adaptive practices by smallholder farmers. However, the study also revealed that inadequate credit facilities, high cost of inputs, limited government support with farm inputs, and little knowledge of CSA practices were the major barriers to investments in CSA practices reported by smallholder farmers. Smallholder farmers should be sensitized to the need to invest in productive farm assets to enable them to absorb risks associated with climate change while at the same time enhancing their ability to uptake essential CSA practices. The findings of this study can be used to inform stakeholders on best practices in mainstreaming CSA into the small-scale agricultural sector.

Regarding policy recommendations, the study findings point to the need to promote CSA practices among smallholder farmers as a resilient measure to adapt to climate change and variabilities. To this end, policymakers ought to design policy measures that focus on building the capacity of smallholder farmers, institutional support, and ensuring that agricultural extension staff works extensively with smallholder farmers. Therefore, targeted training is needed for extension officers on the strategies to cope with climate change and how to apply them in a way that promotes enhanced livelihoods. Understanding the specific needs of the farmers will help design programs to address the barriers constraining them from investing in CSA practices and ensure that they are part of the ongoing agricultural reform programs.

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