

Article

Innovative Climate-Smart Agriculture (CSA) Practices in the Smallholder Farming System of South Africa

Ajuruchukwu Obi *  and Okuhle Maya 

Department of Agricultural Economics & Extension, University of Fort Hare, Alice 5700, South Africa; 201012974@ufh.ac.za

* Correspondence: aobi@ufh.ac.za; Tel.: +27-73-313-1865

Abstract: Climate change is easily the most serious human and environmental crisis of the present generation. While awareness of the existence and consequences of climate change is becoming widespread, the specific effects on agriculture and the extent to which innovative climate-smart agriculture (CSA) practices are being adopted remain unclear. This study was conducted in three local municipalities of the Eastern Cape Province of South Africa to determine the patterns of smallholder choice of alternative climate-smart agricultural practices and the factors affecting such choices. It was particularly crucial to investigate why adaptation of CSA practices continues to be lower than expectation despite awareness of their benefits, thus highlighting the social and cultural limits to adaptation to climate change. A total of 210 households were enumerated on the basis of their involvement in crop and livestock farming. The data were analyzed by means of multinomial logistic model, which was applied separately to individual local municipality data sets and a combined provincial data set, and it was revealed that most farmers were not being sufficiently motivated to move from established practices to adopt new CSA practices. The most influential factors in the decision process as to what CSA practice to adopt were primary occupation, farming system type, household size, age and membership of farmer groups. It seemed that asset fixity constrained farmers to continue with existing practices rather than shift to new, more profitable practices, a situation that can be resolved by external intervention by government agencies and/or other entities. Awareness creation targeting remote rural areas as well as institutions to ease farmers' access to credit and information will contribute to higher adoption rates, which are likely to lead to enhanced food security and standard of living for rural dwellers as their agricultural production and productivity improve.

Keywords: climate change; climate-smart agriculture; multinomial logistic modeling; smallholders; adaptation



Citation: Obi, A.; Maya, O. Innovative Climate-Smart Agriculture (CSA) Practices in the Smallholder Farming System of South Africa. *Sustainability* **2021**, *13*, 6848. <https://doi.org/10.3390/su13126848>

Received: 31 January 2021

Accepted: 26 February 2021

Published: 17 June 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Climate change is easily the most serious human and environmental crisis of the present generation. The African continent and other parts of the developing world are expected to be most disadvantaged by the phenomenon. Numerous studies have investigated the negative effects of climate change on agricultural production and food security in sub-Saharan Africa [1]. The high vulnerability of sub-Saharan African agricultural production to climate change arises largely from the fact that the farming system is mostly rain-fed [2]. Overall, losses experienced in the agricultural sector caused by climate change will result in a decline in gross domestic output and loss of income, thereby worsening the livelihoods of the vulnerable population. Regardless of whether one looks at the picture based on mid-2019 estimates that about 820 million persons were undernourished and 1 billion malnourished worldwide [3], or the recent downward revision of the prevalence of undernourishment (PoU) by the World Bank to 690 million undernourished persons [4], the situation is still desperate. Interestingly, the World Bank's revised estimates were published in mid-2020 when the impacts of COVID-19 were still unfolding [4] and have since

taken a turn for the worse with current statistics showing confirmed cases of 74.3 million, 1.7 million deaths, and 222 countries, areas and territories affected [5]. Importantly, the pandemic has disrupted supply chains for food and inputs and impaired access to markets, which has resulted in deepening poverty through loss of means of livelihoods and growing unemployment, especially among the unskilled and vulnerable groups [6].

As knowledge of the phenomenon of climate change expands, along with awareness of its impacts and consequences, attention necessarily shifts to consideration of the strategies to mitigate these effects. Ultimately, policy interest must focus on the feasibility of implementing climate-smart agriculture (CSA), and whether or not farmers adopt the appropriate CSA practices [7]. The concept of CSA provides a basis for articulating strategies that equip the agricultural sector to diminish the adverse effects of climate change and enhance the capacity of the system to promote food security and sustainable livelihoods [7]. These practices focus on those elements of the farming system that relate to land-use patterns, soil and water conservation, and soil enrichment practices, especially whether or not organic or non-organic fertilizers are employed by farmers, regardless of what part of the world is being considered [8,9]. While these practices have often constituted an important part of many farming systems, their systematic use in combating climate change was only formalized in 2009, as articulated in the FAO report [10] published in that year, and a follow-up paper [11] the following year. Numerous studies have focused on the question of adoption and adaptation of these strategies to either mitigate or eliminate the climate change effects at the level of the smallholder farmers' operations. But the choice among alternative CSA practices can be as important as whether or not CSA practices as a group are adopted since such choices signal the extent to which farmers prefer one practice over the other and afford a basis for determining the optimum resource allocation at both the policy level and the farm level. In general, farmers will choose different adaptation options depending on their perception about the change in climate, their individual judgments on the relative effectiveness of the different strategies, among other considerations. Farmers' adaptation to climate change, behavior and decision-making can be affected by socioeconomic factors, which have been investigated in various countries [12–16]. This paper presents the results of a study designed to determine patterns of smallholder choice among alternative climate-smart agricultural practices and the factors affecting the decision processes, particularly in circumstances where uptake of the CSA practices fell short of expectations.

2. Conceptual Framework

Climate-smart agriculture (CSA) aims to achieve sustainable increases in agricultural productivity and food security among a range of other benefits at the farm level and in the wider economy [17,18]. As highlighted, CSA's central goals are to promote enhanced agricultural productivity, food security, and uplift overall livelihood [17]. These goals can be achieved by making changes to the farming system in relation to the use of existing practices that influence soil fertility and moisture levels that are aligned to the requirements of the crops cultivated in the system [17]. Such system modifications can proceed through application of improved agricultural technologies and innovative practices [19]. The literature has identified the innovations and technologies systematically harnessed for the implementation of CSA as CSA technologies [20–22].

Before the impacts of CSA practices can be manifested, they must be adopted and applied by the farmers in line with appropriate and recommended procedures. Thus, the framework incorporates elements of agricultural innovation systems and adoption behavior. Figure 1 provides indication of the various factors, demographic, institutional, and otherwise, that influence the adoption of these practices. While the correlation of the afore-mentioned categories of factors with adoption of CSA practices is not in question, how the influence is exerted is not very clear in a large number of cases. Similarly, the extent to which the nature of the CSA practice determines whether or not the practice is adopted is also interesting, though still largely unclear. What is known is that the adoption

of agricultural innovations or technologies by farmers, and all users, for that matter, is not automatic but needs to be facilitated in one way or the other. Gaining insights into the nature of action of the influencers and the factors that govern those actions will go a long way toward guiding both researchers and policy makers to make the most optimal decisions in the context of any particular situation. To optimally design an implementation plan for facilitating adoption and productive engagement of the stakeholders with the CSA technologies, it is important to derive a clear idea of the characteristics of smallholder farmers along with the CSA technological options and patterns of information flow at the disposal of the farmers.

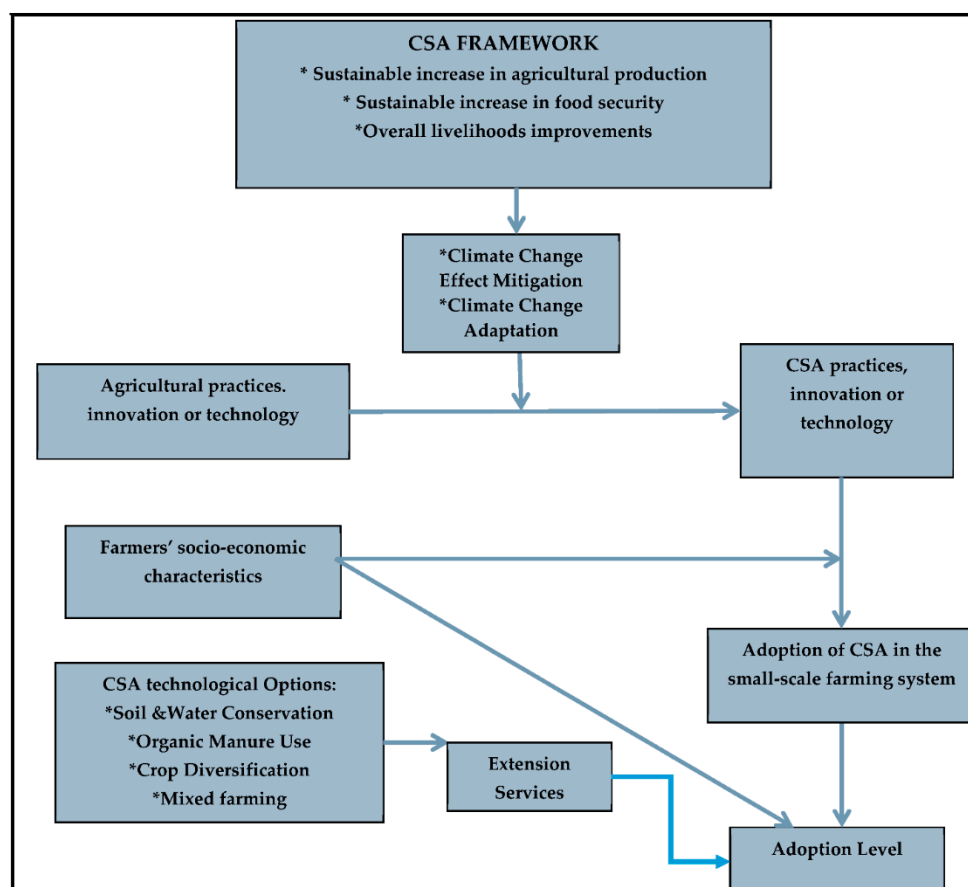


Figure 1. Conceptual framework—Adoption of climate-smart agriculture (CSA) practices among small-scale farmers. Source: Adapted from Abegunde, Melusi and Obi, 2019.

Since the perceptions of farmers about the CSA practices influence their attitudes to the practices, it is important to look at how farmers act on their perceptions. At the same time, one would expect farmers who have experienced and observed climate change to take some actions to respond to the adverse effects of changes in climate. Numerous studies carried out in sub-Saharan Africa, particularly in the regions where a significant number of farmers have experienced a reduction in rainfall, have stated that the response has been by planting low water-requirement crops instead of high water-requirement crops [23–28], whereas farmers in regions where flooding is prevalent have adjusted the planting and harvesting times [29–31]. According to Mandleni and Anim [32], livestock farmers have resorted to keeping livestock that can withstand harsh environments. Several studies indicated that the most used adaptation strategies in African countries are adoption and use of improved crop varieties, planting trees, implementing soil conservation practices, changing planting dates, mixed cropping and involvement in off-farm income-generating activities [26,33–37]. All these considerations were built into the framework.

3. Methodology

3.1. Study Design

The study employed a quantitative approach to evaluate the CSA practices in the farming system and the factors influencing their choice by smallholder farming households in the project area. The study specifically applied a cross-sectional design based on which the sample was selected, and the data collection was conducted.

3.2. Study Areas

Eastern Cape Province is the second largest province in terms of surface area and is considered as the poorest province among the nine provinces of South Africa. The study was conducted in three local municipalities (LMs), which is the lowest level of political administration. The municipalities are Raymond Mhlaba (formerly Nkonkobe Local Municipality), Port St Johns and Ingquza Hill local municipalities, as shown in Figures 2 and 3 and described in the sections that follow below.



Figure 2. Description of the study area. Source: Municipalities of South Africa, 2016.

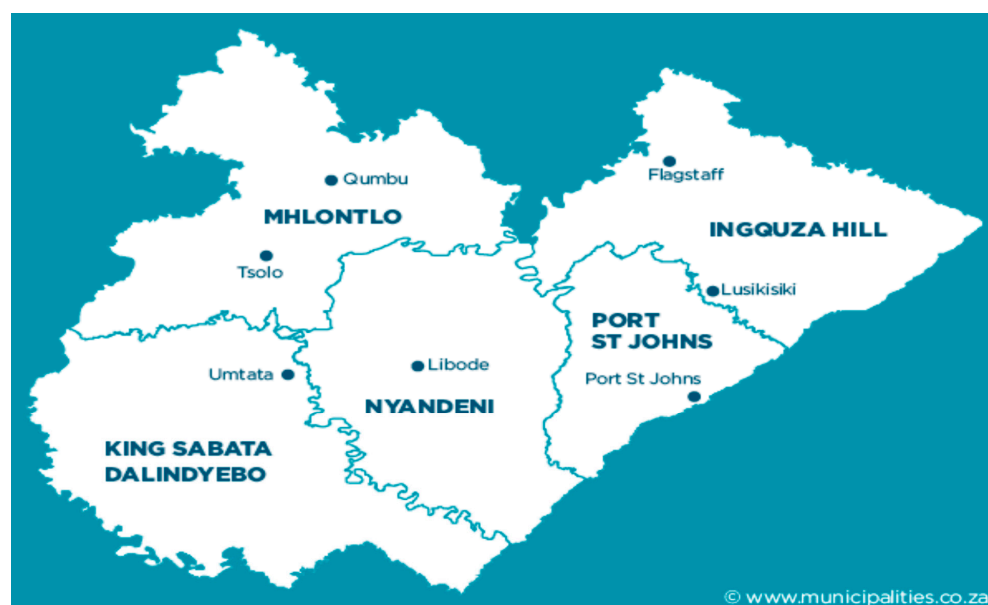


Figure 3. Description of Port St Johns and Ingquza Hill local municipalities. Source: Municipalities of South Africa, 2016.

3.2.1. Raymond Mhlaba Local Municipality.

Raymond Mhlaba local municipality is situated in the Amathole District of the former Ciskei Independent Homeland area of the Eastern Cape Province in South Africa. It was established in August 2016 by merging the Nkonkobe and Nxuba local municipalities. It is now the largest local municipality in the district, taking up 30% of the surface area. It has a total area of 6.357 km² and comprises seven major towns.

The total population of the municipality is 159,515. The unemployment rate of the municipality is 45.05%, with the youth unemployment rate being 56.05%. For their livelihood, the population depends on general government services; wholesale and retail trade; community, social and personal services; finance and insurance; business services; construction. Most of the farming activities take place in the rural areas, which consist of partly owned farms, and this plays a major role in the economic growth of the area.

The climate varies from “arid and semi-arid moderate midlands,” to “arid and semi-arid cold high lying land.” Minimum temperatures are recorded to be 0.1–2 °C in the northern region and 6.1–8 °C in the southern region. Maximum temperatures are recorded to be 0–18 °C in the northern region and 21.9–24 °C in the southern region [38,39]. The northern mountainous regions of the Raymond Mhlaba local municipality have the highest rainfall, recording figures greater than 800 mm per annum, whereas the southern regions record the lowest rainfall with figures of 500–599 mm per annum.

3.2.2. Port Saint Johns (PSJ) Local Municipality

The municipality is situated in the OR Tambo District of the Eastern Cape on the coastal region of the Indian Ocean in the former Transkei homeland. It comprises one urban area and has about 130 rural areas [40]. It is hemmed in by Lusikisiki in the north, Mthatha in the south and Libode in the west. It takes up 11% of the district’s geographical area, making it the smallest local municipality of the five local municipalities in the OR Tambo.

Port St Johns has a population of approximately 165,084, consisting mainly of blacks, with women dominating, at 53% of the population [40]. The local municipality covers a total land area of 1291 km². Despite many poverty alleviation projects in the local municipality under the management of the Department of Social Development, poverty levels are high and remain a source of deep concern. Agriculture and Tourism are among the sectors that have been identified by the municipality to aid in growing the local municipality’s economy. The majority of the population depend on social grants, have high illiteracy rates and have little access to services such as electricity and water.

The climate in PSJ is a moderate, humid and subtropical coastal climate and suitable for growing vegetables in both summer and winter seasons. The average maximum temperature in summer for the area is 25 °C to an average minimum of 20 °C, while in winter the average maximum and minimum temperatures are 21 °C and 8 °C, respectively. Rainfall is received mostly in summer, from October to March. The annual rainfall for Port St Johns is between 1100 and 1400 mm. In general, the area experiences favorable weather conditions, although some years have been marked by extreme climate variations manifested in serious droughts and floods.

3.2.3. Ingquza Hill Local Municipality

Ingquza Hill local municipality [41] is within the OR Tambo District in the Eastern Cape Province. The area measures 2477 km² in land area, which is almost a quarter of the district’s geographical area and is one of the five local municipalities in the district. The municipality has two towns, namely, Lusikisiki and Flagstaff. Ntabankulu and Mbizana local municipalities lie north of the local municipality, while Port St Johns local municipality and the Indian Ocean are located to the south. The total population of the municipality is 278,481 with a population density of 112.4 people per km². The municipality depends mainly on agriculture, trade and manufacturing for livelihoods.

The annual rainfall in the local municipality is 874 mm, receiving most of its rain in summer. It receives the lowest rainfall of 12 mm in July and the highest of 124 mm in

February. Its monthly distribution of average daily maximum temperatures shows that the average midday temperatures range from 19.3 °C in July to 25.5 °C in February.

3.3. Sampling Procedure and Sample Size

A multistage sampling procedure was employed in the study. The two districts selected, namely, Amatole District (for Raymond Mhlaba local municipality) and OR Tambo District (for Port St Johns and Ingquza Hill local municipalities), are the main agricultural districts of the province. For that reason, they were purposively selected. Within these districts, three local municipalities were similarly selected purposively. The three local municipalities selected are notable for their heavy dependence on rain-fed agriculture so that climate change would be very important among the resource-poor small farmers who lack the means for supplemental irrigation. The Port St Johns and Ingquza Hill local municipalities are also important farming areas where most of the available land is devoted to agricultural activities. The Raymond Mhlaba local municipality is representative of other parts of the province where agricultural activities are undertaken alongside significant non-farm activities in a semi-urban setting in close proximity to commercial and administrative infrastructure. Within each local municipality, smallholder households were selected randomly from purposively selected farmer groups involved in both crop and livestock production. The total number of farmers selected and enumerated in this study was 211.

3.4. 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, socioeconomic, institutional factors. Secondary data were collected from the respective district agricultural office, district information desk, district health office, journals, books, records published and unpublished documents and other official reports. Following the data collection process, data were transferred into a spreadsheet for purposes of coding to put them in the appropriate format for analysis using the Statistical Package for Social Sciences (SPSS). Table 1 displays the variables included in the model.

Table 1. Variables and measurement levels used in the multinomial logistic regression model and *a priori* expectations.

Variable Name Dependent Variable	Type of Measurement	Prior Expectations
CSA Practices		
Independent variables		
Gender of HH	Dummy	+
Age of HH	Actual number in years	+
Educational level of HH	Years spent in school	+ / −
Household size	Actual number	+
Land size	Continuous	+ / −
Farming experience	Continuous	+
Access to climate change information	Dummy	+
Access to credit	Dummy	+
Access to extension services	Dummy	+ / −
Distance to market	Dummy	+ / −
Farmer's group membership	Dummy	+

3.5. Analytical Framework

The multinomial logit (MNL) model for climate change adaptation choice specifies the relationship between the probability of choosing alternative options as shown in Equation (1):

$$\Pr(Y_i = j) = \frac{e^{\beta_j X_{ij}}}{1 + \sum_{m=0}^n e^{\beta_m X_{ij}}}, j = 0, 1, 2, 3, \dots, n \quad (1)$$

where β_j is a vector parameter that relates the socioeconomic, farm and institutional characteristics X_i to the probability that $Y_i = j$. Six (6) key climate change adaptation strategies were consolidated into four nominal levels that corresponded to prevalent CSA practices in the project area. Because the probabilities of the six (6) main climate change adaptation strategies must sum to one, a convenient normalization rule is to set one of the parameter vectors, say β_0 , equal to zero ($\beta_0 = 0$). The probabilities for the six alternatives then become [42]:

$$P_j = \Pr(Y_i = j) = \frac{e^{\beta_j X_{ij}}}{1 + \sum_{m=0}^n e^{\beta_m X_{iu}}}, j = 0, 1, 2, 3, \dots, n, \quad (2)$$

$$P_0 \equiv \Pr(Y = 0) = \frac{1}{1 + \sum_{m=1}^n e^{\beta_m X_{iu}}}. \quad (3)$$

The estimated parameters of a multinomial logit system are more difficult to interpret than those in a bivariate (or binomial) choice model. Insight into the effect that the explanatory variables have on the CSA practices choice can be captured by examining the derivative of the probabilities with respect to the k th element of the vector of explanatory variables. These derivatives are defined as:

$$\frac{\partial \Pr(Y = j)}{\partial X_{jk}} = P_j \left[\beta_{jk} - \sum_{m=0}^n \Pr(Y_i = m) \beta_{jk} \right] j = 0, 1, 2, \dots, n; k = 1, \dots, k. \quad (4)$$

Clearly, neither the sign nor the magnitude of the marginal effects need bear any relationship to the sign of the coefficients. The Y_i is the probability of choosing a CSA practice. The following are the main CSA practices used among the smallholder farmers:

1. no adaptation (base category for combined data),
2. crop diversification and new improved crop varieties (base category for municipality data),
3. soil and water conservation practices and planting trees and annual crop rotation,
4. use of organic manure,
5. mixed farming, crop–livestock-based diversification practices,
6. all above practices.

The study considered the choice among the alternative CSA practices by smallholder farmers in each local municipality in order to detect any locational influences in the pattern exhibited by the farmers. Subsequently, the data were combined for the full sample of 210 respondents enumerated to see what the average farmer adaptation behavior was on a province-wide basis. Given that the multinomial outcomes listed above are unordered, the results of the multinomial logit can be interpreted as relative risk ratios (RRRs), which principally present the relationship between predictor variables and CSA practices chosen while also affording a better insight into the longer-term trend in adaptation behavior of the sampled farmers. Since STATA calculates the RRR, which the SPSS does not, the STATA package was used to fit the combined data set because the policy recommendation can be more reasonably made on the basis of likely collective behavior than on the more localized outcomes within local municipalities. In the event, the STATA also afforded an opportunity to use an alternative package to test the model adequacy for the province-wide data to determine the proportionate improvement in the model fit relative to the null, using the McFadden Pseudo R^2 and the Likelihood Ratio Chi-Square Test.

4. Results and Discussion

4.1. Demographic and Socioeconomic Characteristics

The demographic and socioeconomic characteristics of the households were assessed by means of structured interviews. These features referred to the household heads who were enumerated on behalf of their households. The characteristics of interest were gender, age, level of education, household size and main occupation of the household head.

Table 2 presents the results of the descriptive analysis. The results present details on the gender and educational distribution of the household heads, and the occupational structure of the household heads. According to Matebeni [43], gender is an important aspect in a household when it comes to decision-making, especially in rural settings. There were more female-headed households than male-headed in all the study sites. Overall, 58% were female-headed and 42% were male-headed. FAO [44] said that males devote a significant number of hours to off-farm activities while women play a significant role in farming activities. The findings support the notion of agriculture being an activity for women, due to the fact that women pursue duties of being custodians for their families while men often migrate to urban areas in search of better employment opportunities. The distribution of roles between men and women in the rural economies is also evident in such activities as poultry keeping, small stock husbandry and in staple food production [44,45], and it is noted that women in the area work tirelessly toward increasing productivity through their participation in food production [45].

Table 2. Distribution of demographics and socioeconomic characteristics for each study area.

Socioeconomic Characteristics	Raymond Mhlaba		PSJ		Ingquza Hill	
	Frequency (N = 86)	%	Freq. (N = 56)	%	Freq. (N = 69)	%
Gender						
Female	49	57.0	35	63.5	40	58.0
Male	37	43.0	21	37.5	29	42.0
Total	86	100	56	100	69	100
Highest educational level						
No formal education	9	10.5	11	19.6	6	8.7
Primary education	47	54.7	24	42.9	17	24.6
Secondary education	28	32.6	21	37.5	43	62.3
Tertiary education	2	2.3	0	0	3	4.3
Total	86	100	56	100	69	100
Household size						
1–5	63	73.3	32	57.1	40	58.0
6–10	23	26.7	22	39.3	25	36.2
11–15	0	0.0	1	1.8	4	5.8
>15	0	0.0	1	1.8	0	0
Total	86	100	56	100	69	100
Occupation						
Farmer	23	26.7	21	37.5	39	56.5
Wage employment	10	11.6	6	10.7	15	21.7
Employed	18	20.9	10	17.9	8	11.6
Unemployed	35	40.7	19	33.9	7	10.1
Total	86	100	56	100	69	100

The minimum ages of a household head for Raymond Mhlaba, Port St Johns and Ingquza Hill local municipalities were 29, 22 and 18 years, respectively, while the maximum ages of the household head were 84, 85 and 75 years, respectively. The mean average age for the combined sample was 56.02 years. This suggests that many household heads in the local municipalities are fairly experienced in farming, as age often proxies for experience in unskilled rural labor use setting. Age was identified as an important determining factor for the extent of experience (particularly the benefits arising from that) of older people that the household has access to and how much risk-taking a household can accommodate [25,46].

The farmers were further asked about their educational attainment, measured in terms of how many years they spent in school, and the results are presented in Table 2. The results from Table 2 show that 10.5%, 19.6% and 8.7% of the smallholder farmers in Raymond Mhlaba, Port St Johns and Ingquza Hill local municipalities, respectively, never attended school, while about 89.5%, 80.4% and 91.3% of the respondents had some formal education. Out of the respondents that had formal education, about 40.7% of them attended primary

school, 44.1% attended secondary school, while a few respondents, about 3.3%, acquired tertiary qualifications.

According to Table 2, respondents from Ingquza Hill LM had the highest number at 56.5% of household heads with primary occupation in farming. Unemployment rate was highest in Raymond Mhlaba LM, at 40.7%, and lowest in Ingquza Hill LM at 10%, while Port St Johns had about 34% unemployment. For those who were employed, the results show that 21.7% were on wage employment in Ingquza Hill LM while about 10–12% of employed persons in Raymond Mhlaba and Port St Johns had wage employment.

4.2. Choice of CSA Practices by Smallholder Farmers

To address the research question relating to the choice of CSA practices by households, the multinomial logistic regression model was fitted and the results are presented in Tables 3–5. Table 3 presents the results for Raymond Mhlaba LM, Table 4 presents the results for Port St Johns, and Table 5 presents the results for Ingquza Hill LM. The multinomial logistic regression model was used to analyze the factors affecting smallholder farmers' choices of CSA practices. The practices were grouped into six categories because the smallholder farmers adopted more than one strategy. The categories were: "no adaptation"; "crop diversification and new improved crop varieties," "annual crop rotation," "soil and water conservation practices"; "organic manure"; "mixed farming and crop–livestock-based diversification" strategies; and "all CSA practices." In this analysis, "crop diversification and new improved crop varieties" represented one CSA practice and was set as the reference category.

The results from the MNL show that different demographic, socioeconomic factors (age, household size, occupation and education) and institutional factors (membership in farmers' associations and farm systems) affected the smallholder farmers' choices of CSA practices in all three study areas.

According to Table 3, in Raymond Mhlaba LM, the significant factors influencing choice of soil and water conservation and annual crop rotation were occupational category, farming systems type, and household size. The results show that the farmers had a higher likelihood of choosing this particular CSA practice in relation to the base category (crop diversification and new improved crop varieties) when occupational category improved from a previous status. Conversely, the farmers were less likely to choose this CSA practice in relation to the base category when farming systems changed, but were more likely to choose this CSA practice in relation to the base category when household size rose from its current levels.

Table 3 also shows that, in relation to organic manure and crop diversification, households reporting farming as their primary occupation had a higher chance of selecting organic manure + crop diversification (the comparison category) over the reference category (crop diversification + new improved crop varieties). In relation to the use of organic manure and crop diversification, households reporting improved farming system were less likely to select organic manure + crop diversification over crop diversification + new improved varieties; that is, they were likely to choose crop diversification + new improved varieties.

The results in PSJ (Table 4) show that membership in a farmers' association could be significantly ($p < 0.10$) associated with a tendency not to change existing practices in preference for new CSA practices. For instance, a negative coefficient and weak significance was observed where household heads reported membership in a farmers' association with respect to whether or not they moved out of the "no adaptation" category; the negative coefficient suggests that they were more likely to prefer the comparison group to the reference group. This is mainly because being part of a farmers' association provides agricultural information, services and resources useful for adapting to climate change, and these may give the household a feeling of security to continue with old ways.

Table 3. Parameter estimates of the multinomial logit (MNL) analysis of factors affecting choice of adaptation strategies Raymond Mhlaba local municipality.

Independent Variables	No Adaptation		Soil and Water Conservation and Annual Crop Rotation		Organic Manure and Crop Diversification		Mixed Farming and Livestock-Based Diversification Strategies		All Strategies	
	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig
Intercept	63.233	0.982	22.259	0.994	3.380	0.416	17.762	0.003	34.376	0.990
Age	−0.251	0.218	−0.080	0.084 *	−0.39	0.440	−0.133	0.082 *	−0.240	0.971
Membership in farmers' group	−9.294	0.759	−0.551	0.542	−1.179	0.250	−0.378	0.802	−3.419	0.983
Extension services	−9.199	0.776	0.990	0.360	0.965	0.423	−1.896	0.237	0.768	0.996
Occupation	−2.247	0.622	2.306	0.036 **	3.210	0.009 ***	0.725	0.666	6.727	0.973
Education	8.472	0.839	−0.935	0.531	−0.158	0.923	−0.084	0.964	35.708	0.928
Farm experience	−1.027	0.622	−1.131	0.207	−1.237	0.224	−0.190	0.887	0.043	1
Farm systems	2.487	0.270	−3.851	0.002 ***	−4.054	0.003 ***	−0.021	0.989	1.568	0.989
Climate change info	−55.462	0.984	−16.746	0.995	−1.633		−10.390		−73.513	0.979
Household size	−0.058	0.975	1.888	0.039 **	1.888	0.073 *	1.228	0.431	0.702	0.998

Source: Results from SPSS (Version 25.0) generated from field survey, 2018. *** = values statistically significant at 0.01 probability level, ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level. Base category: crop diversification and new improved crop varieties. Number of observations: 86.

Table 4. Parameter estimates of the multinomial logit (MNL) analysis of factors affecting choice of adaptation strategies used in Port St Johns local municipality.

Independent Variables	No Adaptation		Soil and Water Conservation and Annual Crop Rotation		Organic Manure and Crop Diversification		Mixed Farming and Livestock-Based Diversification Strategies		All Strategies	
	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig
Intercept	19.206	0.997	−3.588	1.000	−6.735	0.999	−13.088	0.998	10.225	0.998
Age	0.000	0.996	0.050	0.452	0.610	0.081 *	0.006	0.998	−0.077	0.606
Membership in farmers' group	−3.910	0.082 *	−2.909	0.193	−2.282	0.307	−3.259	0.210	−4.174	0.238
Extension services	−1.733	0.277	−0.473	0.765	−1.960	0.260	−1.550	0.419	−0.268	0.403
Occupation	0.230	0.893	0.808	0.630	0.858	0.590	0.598	0.766	−0.406	0.865
Education	3.474	0.130	3.198	0.161	4.79	0.042 **	17.098	0.988	1.381	0.710
Farm experience	0.678	0.661	1.654	0.261	−0.623	0.694	2.691	0.153	−0.375	0.909
Farm systems	1.151	0.522	−16.368	0.986	1.201	0.485	−0.212	0.920	1.371	0.637
Climate change info	−19.291	0.995	−2.359	1.000	9.869	0.998	−3.612		−23.648	0.994
Household size	0.901	1	3.285	0.999	−14.081	0.997	1.532	1.000	18.369	0.996

Source: Results from SPSS (Version 25.0) generated from field survey, 2018., ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level. Base category: crop diversification and new improved crop varieties. Number of observations: 56.

Table 5. Parameter estimates of the multinomial logit (MNL) analysis of factors affecting choice of adaptation strategies used in Ingquza Hill local municipality.

Independent Variables	No Adaptation		Soil and Water Conservation and Annual Crop Rotation		Organic Manure and Crop Diversification		Mixed Farming and Livestock-based Diversification Strategies		All Strategies	
	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig	Coefficient	Sig
Intercept	3.826	0.814	9.306	0.118	−20.760	0.320	−6.405	0.995	45.581	0.271
Age	−0.027	0.553	−0.096	0.026 **	−0.046	0.287	−0.098	0.093 *	−0.476	0.214
Membership in farmers' group	0.909	0.602	2.935	0.242	1.319	0.459	1.573	0.502	−2.781	0.661
Extension services	−8.267	0.314	−9.797	0.236	−7.134	0.386	−8.651	0.301	−13.720	0.198
Occupation	1.682	0.555	−2.182	0.223	3.353	0.741	1.571	0.636	−1.658	0.836
Education	−1.797	0.350	−1.096	0.548	3.261	0.700	−3.242	0.124	−10.621	0.228
Farm experience	−0.985	0.343	−1.340	0.156	0.008	0.993	−0.665	0.590	−5.758	0.146
Farm systems	−6.193	0.327	−0.533	0.584	−1.174	0.236	−2.104	0.247	−10.410	0.175
Climate change info	−1.015	0.705	4.206	0.545	15.523		12.425	0.990	−8.017	0.132
Household size	6.385	0.647	1.426	0.348	7.051	0.606	6.514	0.703	6.579	0.796

Source: Results from SPSS (Version 25.0) generated from field survey, 2018., ** = values statistically significant at 0.05 probability level, * = values statistically significant at 0.10 probability level. Base category: crop diversification and new improved crop varieties. Number of observations: 69.

According to Tables 3 and 5 the age of the household head was significant for Raymond Mhlaba LM (RMLM) and Ingquza Hill LM (IHLM). For RMLM, the results show that the age of the household head significantly ($p < 0.10$) influenced the choice of the comparison CSA practice in relation to the reference CSA practice. This means that rising age decreased the chances of shifting to new farming practices, probably by 7.7%, compared to using crop diversification and new improved crop varieties. Likewise, for farmers in IHLM, age had an inverse relationship for the same reasons ($p < 0.05$) compared to selecting crop diversification and new improved crop conservation varieties.

Occupation of the household head significantly ($p < 0.05$) influenced the choice of adapting to climate change by using crop rotation, soil and water conservation practices, compared to using crop diversification and new crop varieties for RMLM. This implies that when the household head's main occupation was farming, the probability of adapting to climate change by using crop rotation, soil and water conservation practices was higher by 903.8%, compared to using crop diversification and new improved crop varieties. This means that households whose livelihoods depended on farming were more invested in activities that would improve their production and therefore were able to explore a number of adaptation options.

Farming systems had a negative relationship concerning the probability of farmers using crop rotation, soil and water conservation practices but significantly ($p < 0.01$) influenced the choice of adapting to climate change. As illustrated in Table 3, the choice of farming system used reduced the probability of using crop rotation, soil and water conservation practices as an adaptation strategy by 98%, compared to adapting by using crop diversification and new improved crop varieties.

The impact of household size on the choice of using crop rotation, soil and water conservation practices compared to using crop diversification and new improved crop varieties was positive for farmers in Raymond Mhlaba LM. The size of a household significantly ($p < 0.05$) influenced the choice of using crop rotation, soil and crop conservation practices instead of the reference category. This means an addition of one person to a household meant the household had a higher chance of using crop rotation, soil and water conservation practices than of choosing to adapt to climate change by using crop diversification and new improved crop varieties. The findings of this study agree with the expected outcome, as speculated in the methodology, that as the household size grows the more likely it is to use adaptation strategies to climate change. However, a recent study by Abegunde et al. [22] found that household size did not influence choice among small-scale farmers in Kwazulu-Natal Province of South Africa.

Age was significantly and negatively correlated to the probability of choosing mixed farming and crop–livestock-based diversification strategies to changes in climate in both Raymond Mhlaba and Ingquza Hill LMs (Tables 3 and 5). This shows that younger farmers had the greater ability to cope with the changes in climate than the older farmers. These findings agree with those of Nhemachena et al. [25], which revealed age as negatively influencing the probability of farmers' picking and using mono crop–livestock under irrigation. Abegunde et al. [22] reached the same conclusion on the basis of data from the Kwazulu-Natal Province of South Africa.

The level of education had a positive effect on the choice of CSA practice by farmers in PSJ. Years spent in school acquiring education positively and significantly ($p < 0.05$) influenced the decision to adapt to climate change by using application of organic manure as a strategy. Onyenekwe et al. [47] found educational attainment to be similarly influential in the decision to adopt CSA practices in Nigeria. Abegunde et al. [22] also found in the Kwazulu-Natal Province that the educational level of respondents positively influenced their choice of CSA practices. This finding also agrees with international experience that suggests that education enhances the opportunities to access new information that contributes to skills and know-how to apply improved technologies [48]. This implies that as the farmer's educational level rose, they were more likely to prefer organic manure and crop diversification than crop diversification and new improved crop varieties. It is believed

that more years spent acquiring knowledge exposed the farmers to more information, thereby making it easier for them to make informed choices as well as increasing the chance of using new technology, which they would stand a greater chance of understanding more clearly.

Table 6 presents the results of the parameter estimates of the multinomial logit model for the combined data for the entire province. In this case, the “no adaptation” option was chosen as the base outcome and the analysis was run on the STATA package. The full set of identified CSA practices for the entire province were used, namely, “no adaptation,” “crop diversification and new improved crop varieties,” “soil and water conservation practices and planting trees and annual crop rotation,” “use of organic manure,” “mixed farming, crop–livestock-based diversification practices,” and “all CSA practices.” The indication was that the choice of practices was much more complex than generally suggested by available studies, which give the impression that smallholders are able to make clear-cut decisions about the practices they adapt. It may seem that farmers can adapt a wide variety of practices at the same time, especially in the multi-enterprise situations in which many of them operate. In this study, it seemed that age, household size, number of children in household and membership in farmer organizations were important determinants of whether or not smallholder farmers adapted by way of crop diversification and new improved crop varieties in relation to not adapting at all. The results suggest that those who currently fell into that category (crop diversification and improved crop varieties) were likely to prefer it to all other options if they were older, had larger families and more children, and were members of farmer groups. When the four significant predictors were compared among themselves on the basis of the relative risk ratio (RRR), it was clear that membership in farmer groups was more likely to result in a strong preference for the chosen option than any of the other factors. On the other hand, age and household size may not have been very important, given that their RRRs were less than 1.

Table 6. Parameter estimates of the multinomial logit (MNL) analysis of factors affecting smallholder farmers’ choices of adaptation strategies for the Eastern Cape.

Variables	RRR	Std. Err.	Z	P > z	[95% conf. Interval]	
1 (base outcome). No Adaptation						
2. Crop Diversification						
Age	0.9658853	0.0175859	−1.91	0.057 *	−0.9320252	1.000975
Household size	0.7618357	0.0736889	−2.81	0.005 ***	0.6302727	0.9208612
No. of children	1.651443	0.2381629	3.48	0.001 ***	1.244823	2.190886
Farm size	1.156666	0.3999146	0.42	0.674	0.5873632	2.277765
Climate change info	2.18998	1.26397	1.36	0.174	0.706578	6.787662
Access to extension	1.371496	1.234076	0.35	0.726	0.2351156	8.00033
Extension visits	1.324938	0.3577056	1.04	0.297	0.7805283	2.249066
Farm group membership	6.329912	4.264825	2.74	0.006 ***	1.69003	23.70833
Cc13	1.178133	1.437016	0.13	0.893	0.1078822	12.86586
Constant	0.2460182	0.6079592	−0.57	0.570	0.0019386	31.22144
3. Soil and Water Conservation, Tree Planting and Crop Rotation						
Age	0.9701846	0.0201717	−1.46	0.145	0.9314436	1.010537
Household size	0.8436013	0.0897635	−1.60	0.110	0.684802	1.039225
No. of children	1.713724	0.2655604	3.48	0.001 ***	1.264846	2.321902
Farm size	1.411189	0.5206913	0.93	0.351	0.6847225	2.908412
Climate change info	3.121419	2.284822	1.56	0.120	0.7435118	13.10437
Access to extension	0.3877754	0.4142336	−0.89	0.375	0.047786	3.146733
Extension visits	1.033097	0.3203525	0.11	0.916	0.5625908	1.897098
Farm group membership	6.368277	4.793164	2.46	0.014 **	1.456647	27.8413
Cc13	1.60×10^{-7}	0.0003095	−0.01	0.994	0	0
Constant	1153066	2.23×10^9	0.01	0.994	0	0

Table 6. Cont.

Variables	RRR	Std. Err.	Z	P > z	[95% conf. Interval]	
4. Organic Manure						
Age	0.9191328	0.0284377	−2.73	0.006 ***	0.8650523	0.9765943
Household size	0.5748322	0.1122283	−2.84	0.005 ***	0.3920625	0.8428046
No. of children	1.816063	0.3749842	2.89	0.004 ***	1.211638	2.722003
Farm size	0.0102919	0.0165304	−2.85	0.004 ***	0.0004419	0.2396947
Climate change info	9.628336	9.914467	2.20	0.028 **	1.279541	72.45167
Access to extension	1.831736	2.747764	0.40	0.687	0.0968248	34.65289
Extension visits	0.5365399	0.3843529	−0.87	0.385	0.1317771	2.184562
Farm group membership	2.754705	2.529491	1.10	0.270	0.455475	16.66041
Cc13	1.13×10^{-7}	0.000276	−0.01	0.995	0	0
Constant	3.59×10^7	8.77×10^{-10}	0.01	0.994	0	0
5. Mixed Farming—Crop–Livestock Integration						
Age	0.971378	0.0309254	−0.91	0.362	0.9126176	1.033922
Household size	0.6878722	0.1244885	−2.07	0.039 *	0.4824592	0.9807424
No. of children	1.403407	0.2854353	1.67	0.096	0.9420198	2.090775
Farm size	1.088701	0.714239	0.13	0.897	0.3009403	3.938554
Climate change info	0.353286	0.3247828	−1.13	0.258	0.0582908	2.141178
Access to extension	71.54411	130.8409	2.34	0.020 **	1.985563	2577.888
Extension visits	2.759015	1.575731	1.78	0.076	0.9007724	8.450704
Farm group membership	2.371864	2.486541	0.82	0.410	0.3039021	18.51169
Cc13	86.45048	120.5724	3.20	0.001 ***	5.618208	1330.261
Constant	0.0000368	0.0001569	−2.39	0.017 **	8.57×10^{-9}	0.1576295
6. All CSA Practices						
Age	0.9557315	0.0230582	−1.88	0.061	0.91159	1.00201
Household size	0.764272	0.0963427	−2.13	0.033 *	0.5969625	0.9784731
No. of children	1.87237	0.3157592	3.72	0.000 ***	1.345376	2.605791
Farm size	2.356742	0.9105252	2.22	0.026 **	1.105226	5.025428
Climate change info	2.476592	1.867663	1.20	0.229	0.5648602	10.85845
Access to extension	0.6575272	0.7879001	−0.35	0.726	0.0627969	6.884769
Extension visits	0.5033642	0.2331093	−1.48	0.138	0.20309	1.247602
Farm group membership	5.740974	4.767332	2.10	0.035 *	1.12757	29.22991
Cc13	3.298846	4.19877	0.94	0.348	0.2722407	39.9734
Constant	0.1498677	0.4627316	−0.61	0.539	0.0003528	63.66177

Number of observations = 210; LR chi2(45) = 176.31; Prob > chi2 = 0.0000; Pseudo R2 = 0.2545; Log likelihood = −258.17718.

In the cases of those farmers who currently adapted by way of applying soil and water conservation, tree planting and crop rotation, Table 6 suggests that number of children living in the household and farmer group membership were the influential factors. Again, the RRR of 6.4 suggests that farmer group membership increased the likelihood that the farmers would prefer what they are currently doing to any other alternative.

For farmers currently adapting by using organic manure in their farming practices, the significant predictors were age, household size, number of children, farm size and having climate change information. The results show that older smallholder farmers who were currently using organic manure were more likely to shift to the alternative options (perhaps the no adaptation), as much as farmers heading larger households and owning larger farms. The possible reasons could be that organic farming is much more specialized than the conventional farming and is an undertaking best operated by younger and more adventurous farmers. Older farmers who undertake organic farming can only manage small farm sizes.

Mixed farming households seem to have been influenced more by household size, access to extension services and awareness of climate change effects. It seems that larger household size led to a farming household considering the comparison options as more attractive than the one they were practicing, while access to extension services and climate change awareness were likely to result in stronger preference for the existing adaptation

practice (that is, mixed farming). Obviously, integration of livestock and crops in a farming system requires expertise and experience that are facilitated through intervention of a dedicated extension service. The RRR of 86.45048 confirms the important role of climate change awareness in determining the choice of adaptation strategy with respect to complex farming systems such as crop–livestock integration.

As suggested earlier, farmers can engage in multiple CSA practices at the same time, and there is the possibility that one farmer can concurrently make the full range of adaptation strategies on different segments of the enterprises he or she undertakes. For that reason, this study identified a category that represented such a multiple-choice pattern. The results presented in Table 6 suggest that number of children and farm size were positive determinants of such multiple choices, the indication being that farm size was more than twice as likely as the other factor to lead to the household choosing to adapt in multiple ways. In a multi-plot farming system, a farmer can practice alternative systems while also maintaining a livestock herd and other farming activities. The larger the farm sizes and number of farming units, the more likely is this situation to arise. The number of children in the household reflects the age of the farmer and the level of responsibility.

5. Discussions, Conclusions and Recommendations

5.1. Discussions and Conclusions

The most obvious conclusion to draw from the foregoing results is the relative stability of the farming system in relation to the adoption and adaptation of new practices to mitigate the effects of climate change. Over much of the three local municipalities enumerated, farmers were not significantly motivated to move from practices that they were currently undertaking to embrace new ones. At the same time, the majority of the farmers seemed to have experienced the changes in climate as well as the impacts of climate change. The smallholder farmers in the study areas were affected by droughts, decreased rainfall and, in some cases, floods. But the most common feature of all these municipalities was that they lacked access to extension services, credit and farm inputs. Some of these farmers used indigenous knowledge in order to counteract the shocks of climate change. Some farmers were also reported to have been steering toward adaptation. This was achieved by planting different plant varieties, annual crop rotation, changing planting dates and using less costly actions, such as using organic manure and rainwater harvesting for irrigation. It is possible that due to the activities of a number of NGOs in the areas, farmers were already doing things that amounted to positive responses to climate change and passed for climate-smart farming.

Looking at the wider provincial data reveals more or less similar patterns. Much of the observed response reflected a preference for existing practices rather than shifting to alternatives. Most of the predictors inserted in the model were shown not to exert any significant effect in the pattern of adaptation of CSA practices in the farming system. This mirrored the pattern observed for the individual local municipalities, where there seemed to be a tendency to continue doing what the farmers were already doing rather than shift to alternatives. These patterns reflect fundamental issues with the farming systems that may be explained by the ease with which farmers could transition between practices, regardless of how much information they possessed about the relative advantages. In this particular situation, it seemed that farmers were well aware of the key issues related to climate change and the advantages of the alternative practices, and yet they were less eager to make changes, as would have been expected.

Almost always, such rigidity and sticking to existing practices is a reflection of asset fixity, which is a serious handicap in many traditional farming systems, including those of South Africa [49]. The farmers are severely resource-constrained despite recent government policies in favor of agricultural transformation. Such constraints mean that the farmers cannot leave existing practices without incurring substantial costs; it is generally safer to continue doing what they are used to, even if farm productivity and profitability are as low as they are in the Eastern Cape Province at present. It is therefore possible that these

farmers will be locked in the low equilibrium traps until they are rescued and freed from those traps by external intervention, such as support from a government agency like the Department of Rural Development and Agrarian Reform (DRDAR) and those operating at the national level.

A key limitation of the study relates to the inherent difficulties with collecting the relevant information on the adaptation decision-making processes among smallholder farmers. While adaptation makes it possible for under-resourced farmers to blunt some of the more pernicious effects of climate change, not all farmers end up utilizing that strategy. The reason for this state of affairs could be a number of host of factors that influence adaptation, including “ethics, knowledge, attitudes to risk and culture” [50]. However, precise measurement of these elements remains a challenge and, along with other studies, this study is only able to make educated guesses about the extent to which they influence the choice of alternative adaptive strategies among rural farming households.

5.2. Recommendations

In line with the foregoing, on the assumption that farmers in the area are reasonably aware of the implications of ongoing climate change but are incapable of making costless transitions to more profitable alternatives, there is a need to incorporate indigenous knowledge-based systems in the programming of rural development in the area. These indigenous-based knowledge systems provide insights to policy makers on what explains the seemingly perverse responses of local farmers, who continue doing what they have been doing even when it is clear that they are not profiting. When policy makers are armed with such knowledge and are able to combine it with the advanced scientific systems already at their disposal, they are able to design policies that release the farmers from their low-level equilibrium traps and empower them to withstand the impacts of climate change by adapting more efficient systems. Of course, sight is not lost of the fact that there are still those farmers in the more remote parts of the province who actually lack information about the serious problems posed by climate change. Many parts of the province are still disadvantaged by infrastructure deficiencies and maybe too remote for easy access by extension services. There are also parts of the PSJ local municipality where telephone networks are either weak or non-existent. This calls for greater awareness-raising programs that have wider provincial coverage. 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 be helpful in designing programs to address their core constraints to ensure that they are part of the ongoing agricultural reform programs. These farmers should also be encouraged and enabled to be part of social and farmer groups through which they can receive information about programs that are beneficial to their farm operations. It will be recalled that the analysis revealed that membership in farmer groups played a role in some instances in the decisions farmers took regarding adaptation of CSA practices in the sample area. Additionally, interactions between farmers and extension officers, and among farmers themselves, with the aim of building stronger know-how on how to analyze and interpret information on climate, should be institutionalized.

Over and above the foregoing, adapting to climate change requires access to financial resources and support. A number of farmers mostly used organic manure, diversifying crops and other simpler, inexpensive adaptation strategies. Lack of access to credit ordinarily makes it difficult for farmers elsewhere and in the study area to adapt to more efficient and effective adaptation strategies. Therefore, there is a need for establishment of financial institutions in rural areas to cater to the needs of the underprivileged smallholder farmers. Such institutions can be owned/managed by government or private financial institutions. This will improve the farmers’ adaptive capacity in response to climate change and enable them to embrace more profitable crop, soil and livestock management strategies. These observations and their possible implications call for planning and programming models that are more inclusive of local knowledge. It is also necessary to establish mechanisms for

measuring the qualitative attributes that govern the adaptation decision-making process in order to enhance understanding of the reasons farmers are unable to adopt and adapt practices that improve their conditions and livelihoods.

Author Contributions: Conceptualization A.O. and O.M.; methodology, A.O. and O.M.; software, A.O.; validation, A.O.; formal analysis, O.M.; investigation, O.M.; resources, O.M.; data curation, O.M.; writing—original draft preparation, A.O. and O.M.; writing—review and editing, A.O.; supervision, A.O.; project administration, A.O.; funding acquisition, A.O. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the South African Water Research Commission (WRC) and the South African Agricultural Research Council (ARC). The financial support is gratefully acknowledged.

Acknowledgments: The Water Research Commission (WRC) and Agricultural Research Council (ARC) of South Africa funded this research and the authors are grateful for the support. We acknowledge the active participation, time and commitment of the participant farmers.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Ringer, C.; Zhu, T.; Cai, X.; Koo, J.; Wang, D. Climate change impacts on food security in sub-Saharan Africa: Insights from comprehensive change scenarios. In *IFPRI Discussion Paper 01042*; International Food Policy Research Institute: Washington, DC, USA, 2010.
2. Belloumi, M. *Investigating the Impact of Climate Change on Agricultural Production in Eastern and Southern African Countries*; African Growth & Development Policy (AGRODEP) Working Paper; International Food Policy Research Institute (IFPRI): Washington, DC, USA, 2014; Volume 3, pp. 1–27.
3. WHO. *World Hunger is Still not Going Down after Three Years—More than 820 Million People are Hungry Globally*; World Health Organization: Geneva, Switzerland, 2019; Available online: <https://www.who.int/news/item> (accessed on 18 December 2020).
4. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2019: Safeguarding against Economic Slowdowns and Downturns*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2019; pp. 1–239.
5. WHO. Coronavirus Disease (COVID-19) Pandemic. *Geneva, World Health Organization*. Update of 19 December 2020. Available online: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019?> (accessed on 19 December 2020).
6. World Bank. Food Security and COVID-19. 2020. Available online: <https://www.worldbank.org/en/topic/agriculture/brief/food-security-and-covid-19> (accessed on 19 December 2020).
7. FAO. *Climate-Smart Agriculture Sourcebook*; Food and Agriculture Organization of the United Nations, Department NRMaE: Rome, Italy, 2013.
8. Serdeczny, O.; Adams, S.; Baarsch, F.; Coumou, D.; Robinson, A.; Hare, W.; Schaeffer, M.; Perrette, M.; Reinhardt, J. Climate change impacts in sub-Saharan Africa: From physical changes to their social repercussions. *Reg. Environ. Chang.* **2015**, *15*, 1–19.
9. National Research Council. *Soil and Water Quality: An Agenda for Agriculture*; The National Academies Press: Washington, DC, USA, 1993.
10. FAO. *Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies*; FAO: Rome, Italy, 2009; pp. 1–84. Available online: <http://www.fao.org/docrep/012/i1318e/i1318e00.pdf> (accessed on 19 December 2020).
11. FAO. *Climate-Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation*; FAO: Rome, Italy, 2010.
12. Pereira, L. *Climate Change Impacts on Agriculture across Africa*; Oxford Research Encyclopedia of Environmental Science: Centre for Complex Systems in Transition; Stellenbosch University: Stellenbosch, South Africa, 2017; pp. 1–35.
13. Kom, Z.; Nethengwe, N.S.; Mpandeli, N.S.; Chikoore, H. Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal* **2020**, 1–24. [CrossRef]
14. Abegunde, V.O.; Sibanda, M.; Obi, A. Determinants of the adoption of climate-smart agricultural practices by small-scale farming households in King Cetshwayo District Municipality, South Africa. *Sustainability* **2019**, *11*, 195.
15. Branca, G.; McCarthy, N.; Lipper, L.; Jolejole, M. *Climate Smart Agriculture: A synthesis of Empirical Evidence of Food Security and Mitigation Benefits from Improved Cropland Management*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2011.
16. Kitsao, E.Z. Adoption of Climate Smart Agriculture (CSA) technologies among female smallholder farmers in Malawi. Master's Thesis, Norwegian University of Life Sciences, Ås in Viken, Norway, 2016.
17. Lipper, L.; Thornton, P.; Campbell, B.M.; Baedeker, T.; Braimoh, A.; Bwalya, M.; Caron, P.; Cattaneo, A.; Garrity, D.; Henry, K.; et al. Climate-smart agriculture for food security. *Nat. Clim. Chang.* **2014**, *4*, 1068–1072.
18. Lipper, L.; McCarthy, N.; Zilberman, D.; Asfaw, S.; Branca, G. (Eds.) *Climate Smart Agriculture: Building Resilience to Climate Change*; Food and Agriculture Organization of the United Nations (FAO)/Springer: Rome, Italy, 2018; pp. 1–625.
19. Abid, M.; Scheffran, J.; Schneider, U.A.; Ashfaq, M. Farmers' perceptions of and adaptation strategies to climate change and their determinants: The case of Punjab province, Pakistan. *Earth Syst. Dynam.* **2015**, *6*, 225–243.

20. Bahinipati, C.S.; Venkatachalam, L. What drives farmers to adopt farm-level adaptation practices to climate extremes: Empirical evidence from Odisha, India. *Int. J. Disaster Risk Reduct.* **2015**, *14*, 347–356.
21. Komba, C.; Muchapondwa, E. *Adaptation to Climate Change by Smallholder Farmers in Tanzania*; Environment for Development, Discussion Paper Series; EfD DP 15e12; University of Gothenburg: Gothenburg, Sweden, 2015.
22. Abegunde, V.O.; Sibanda, M.; Obi, A. The dynamics of climate change adaptation in sub-Saharan Africa: A review of Climate-Smart Agriculture among Small-Scale Farmers. *Climate* **2019**, *7*, 1–23.
23. De Wit, M. The Perception of and adaptation to climate change in Africa. In *CEEPA Discussion Paper No. 10*, CEEPA; University of Pretoria: Pretoria, South Africa, 2006.
24. Yesuf, M.; Di Falco, S.; Deressa, T.; Ringler, C.; Kohlin, G. *The Impact of Climate Change and Adaptation on Food Production in Low-Income Countries: Evidence from the Nile Basin, Ethiopia*, EDRI; International Food Policy Research Institute (IFPRI) & Ethiopia Development Research Institute (EDRI): Washington, DC, USA, 2008.
25. Nhemachena, C.; Hassan, R. *Micro-Level Analysis of Farmers' Adaptations to Climate Change in Southern Africa*; IFPRI, Environment and Production Technology Division, International Food Policy Research Institute: Washington, DC, USA, 2007; Available online: https://www.researchgate.net/publication/5056602_MicroLevel_Analysis_of_Farmers\T1\textquoteright_Adaptation_to_Climate_Change_in_Southern_Africa (accessed on 12 December 2020).
26. Gandure, S.; Walker, S.; Botha, J.J. Farmers' perceptions of adaptation to climate change and water in a Southern African rural community. *Econ. Dev.* **2012**. [CrossRef]
27. Deressa, T.T.; Hassan, R.M.; Ringler, C.; Alemu, T.; Yesuf, M. *Analysis of the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia*; IFPRI Discussion Paper No. 798; International Food Policy Research Institute: Washington, DC, USA, 2008.
28. Juana, J.; Kahaka, Z.; Okurut, F. Farmers' Perceptions and Adaptations to Climate Change in Sub-Sahara Africa: A Synthesis of Empirical Studies and Implications for Public Policy in African Agriculture. *J. Agric. Sci.* **2013**, *5*, 121–135.
29. Acquah-de Graft, H. Farmers' perceptions and adaptation to climate change: A willingness to pay analysis. *AGRIS on-line Papers in Economics and Informatics*, Czech University of Life Sciences Prague, Faculty of Economics and Management. *J. Agri. Sci.* **2011**, *3*, 1–9. [CrossRef]
30. Acquah-de Graft, H.; Onumah, E. Farmers' perceptions and adaptations to climate change: An estimation of willingness to pay. *Agris* **2011**, *3*, 31–39.
31. Fosu-Mensah, B.; Vlek, P.; Manschadi, M. *Farmers' Perceptions and Adaptation to Climate Change: A Case Study of Seky edumase District in Ghana. World Food System—A Contribution from Europe*; Centre for Development Research (ZEF), University of Bonn: Bonn, Germany, 2010.
32. Mandleni, B.; Anim, F. Perceptions of Cattle and Sheep Framers on Climate Change and Adaptations in the Eastern Cape Province of South Africa. *J. Hum. Ecol.* **2011**, *34*, 107–112.
33. Deressa, T.T.; Hassan, R.M.; Ringler, C.; Alemu, T.; Yesuf, M. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Glob. Environ. Chang.* **2009**, *19*, 248–255.
34. Kabubo-Mariara, J. Climate change adaptation and livestock activity choices in Kenya: An economic analysis. *Nat. Resour. Forum.* **2008**, *32*, 131–141.
35. Mideksa, T.K. Economic and distributional impacts of climate change: The case of Ethiopia. *Global Environ. Chang.* **2009**, *20*, 278–286.
36. Sofoluwe, N.; Tijani, A.; Baruwa, O. Farmers' Perception and Adaptations to Climate Change in Osun State, Nigera. *Afr. J. Agric. Res.* **2011**, *6*, 4789–4794.
37. Bryan, E.; Deressa, T.T.; Gbetibouo, G.A.; Ringler, C. Adaptation to climate change in Ethiopia: Options and constraints. *Environ. Sci. Policy* **2009**, *12*, 413–426.
38. RMFRIDP. Raymond Mhlaba Final Reviewed Integrated Development Plan 2020–2021. 2020. Available online: <http://www.raymondmhlaba.gov.za/system/files/data/IDP-SDBIP/June-2020/Final%20IDP%202020-2021.pdf> (accessed on 3 March 2021).
39. StatsSA. Census of Commercial Agriculture. 2017; Eastern Cape Financial and Production Statistics. Available online: <http://www.statssa.gov.za/publications/Report-11--02--03/Report-11--02-> (accessed on 12 December 2020).
40. StatsSA. Port St. John Municipality. 2020. Available online: http://www.statssa.gov.za/?page_id=993&id=port-st-johns-municipality (accessed on 12 December 2020).
41. StatsSA. Ingquza Hill Local Municipality. Available online: <http://www.statssa.gov.za/?s=municipality+population&sitem=statistics+by+place&pg=2&paged=4> (accessed on 12 December 2020).
42. Greene, W.H. *Econometric Analysis*, 4th ed.; Prentice Hall: Englewood Cliffs, NJ, USA, 2000.
43. Matebeni, F. Measuring rural household food security in the Nkonkobe Local Municipality, Eastern Cape Province of South Africa. Master's Dissertation, Faculty of Agricultural Science, Stellenbosch University, Stellenbosch, South Africa, 2018.
44. FAO. The role of women in agriculture. In *ESA Working Paper No. 11–02*; Food and Agriculture Organization of the United Nations: Rome, Italy, 2011.
45. Mcata, B. The Role of Home Gardens in Enhancing Food Security in Rural and Urban Areas: A case study of Nkonkobe Municipality, Eastern Cape-South Africa. Master's Dissertation, Faculty of Science and Agriculture, University of Fort Hare, Alice, South Africa, 2012.

-
46. Muchara, B. Analysis of food value chain in smallholder crop and livestock enterprises in Eastern Cape Province of South Africa. Master's Dissertation, Faculty of Science and Agriculture, University of Fort Hare, Alice, South Africa, 2011.
 47. Onyeneke, R.U.; Igberi, C.O.; Uwadoka, C.O.; Aligbe, J.O. Status of climate-smart agriculture in southeast Nigeria. *GeoJournal* **2018**, *83*, 333–346.
 48. Maddison, D. *The Perception of and Adaptation to Climate Change in Africa*; Policy Research Working Paper, No WPS 4308; The World Bank: Washington, DC, USA, 2007.
 49. Obi, A. Smallholder agriculture and prosperity: Trade-offs, synergies and everything in between. In *Professorial Inaugural Lecture 5 October 2015*; University of Fort Hare: Alice, South Africa, 2015.
 50. Adger, W.N.; Dessai, S.; Goukken, M.; Nelson, D.R.; Wreford, A. Are there social limits to adaptation to climate change? *Clim. Chang.* **2009**, *93*, 335–354.