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**Factors affecting level of use and applicability of Climate-Smart Agriculture practices  
and implications for food security of small-scale farming households in KwaZulu-Natal  
Province of South Africa**

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## ABSTRACT

Climate-Smart Agriculture (CSA) has been identified to have the potential of creating a sustainable agricultural system and enhance food security under changing climatic conditions. However, experience has shown that some recommended solutions have not proven to be suitable in many contexts, particularly in developing countries after they might have committed their scarce resources in embracing such recommendations. Furthermore, the level of adoption among farmers has shown that CSA adoption is not automatic despite its potential. Hence, this study assessed the factors affecting the level of use and applicability of CSA in the small-scale farming system, with its implications on the food security of small-scale farming households in KwaZulu-Natal (KZN) province of South Africa.

This study adopted a cross-sectional research design, a quantitative research approach and multi-stage sampling techniques. Data were generated from 327 small-scale farmers through structured interviews using close-ended questionnaires. A comparative analysis was conducted on two local municipalities (Mthonjaneni and uMhlathuze Local Municipalities) purposively selected based on their agricultural potentials. The analysis made use of Adaptation Strategy Use Index (ASUI), Acceptance Level Index (ALI), Composite Score Index (CSI), Generalized Ordered Logit Regression (gologit), Ordinary Least Squares (OLS) Regression, Household Dietary Diversity Score (HDDS), Household Food Consumption Score (HFCS) and the Binary Logistic Regression Model.

Results show that most (81%, 74% and 65%) of the sampled farmers, with an ASUI of 313, 289 and 249, respectively, reported the use of organic manure, rotational cropping and planting of drought and heat tolerant crops, respectively, as the popular CSA practices adopted for crop production. Concerning livestock farmers, most (83% and 70%) of the sampled farmers with an ASUI of 116 and 104, respectively, reported the use of improved grazing and efficient manure management, respectively, as the commonly adopted CSA practices. For mixed farming, most (87% and 83%) with an ASUI of 292 and 282, respectively, reported the use of organic manure and integrated crop-livestock management and rotational cropping, respectively, as the popular CSA practices.

The majority (57%) of the sampled farmers fell in the medium category of users of CSA practices, while the lowest proportion (18%) fell in the high user category in Mthonjaneni. Farming experience ( $p = 0.010$ ), distance of farm to homestead ( $p = 0.104$ ), contact with agricultural extension agents ( $p = 0.052$ ), exposure to media ( $p = 0.061$ ), agricultural

production activity ( $p = 0.004$ ), membership of an agricultural-related group ( $p = 0.059$ ) and the perception of the effect of climate change ( $p = 0.003$ ) were found to be statistically and positively significant with CSA adoption level of the sampled farming households. However, off-farm income was found to be statistically and negatively significant ( $p = 0.061$ ) with CSA adoption level. Educational status ( $p = 0.080$ ) was found to have a statistically significant and positive effect on CSA adoption level in uMhlathuze. Results for Mthonjaneni reveal that farm income ( $p = 0.015$ ), marital status ( $p = 0.054$  for the low user category,  $p = 0.059$  for the medium user category), agricultural production activity ( $p = 0.001$  for the low category and  $p = 0.049$  for the medium category) and the perception of the effect of climate change ( $p = 0.036$  for the low user category and  $p = 0.001$  for the medium user category) were statistically and positively significant with CSA adoption level.

Furthermore, agroforestry (ALI = 559), cultivation of cover crops (ALI = 574) and diet improvement for animals (ALI = 554), were highly accepted by the farmers concerning social compatibility, while the use of organic manure (ALI = 545), rotational cropping (ALI = 529), mulching (ALI = 525) and cultivation of cover crops (ALI = 533), were highly accepted by the farmers concerning technical compatibility. In terms of economic compatibility, the farmers showed high preference for organic manure (ALI = 542), rotational cropping (ALI = 515) and mulching (ALI = 541), while the use of organic manure (ALI = 524) was highly embraced based on environmental compatibility. CSA adoption had a positive significant effect on Mthonjaneni, uMhlathuze and the combined analysis (KCDM) at 1 per cent ( $p = 0.000$ ), 5 per cent ( $p = 0.025$ ) and 1 per cent ( $p = 0.000$ ), respectively. The OLS regression model used predicts that the adoption of an additional CSA practice would increase the total value product of the farmers by about ZAR 309, ZAR 212 and ZAR 199 in Mthonjaneni, uMhlathuze and KCDM, respectively.

Results further show that about 38 per cent were in the high dietary diversity category (HDDS  $\geq 7$ ), about 38 per cent in the medium dietary diversity (HDDS = 4 - 6), while only 24 per cent were in the low dietary diversity category (HDDS  $\leq 3$ ). The majority (80%) of the sampled farmers had an acceptable food consumption (HFCS  $> 35$ ). Overall, taking the HDDS as a proxy for food security, the majority (62%) of the sampled farming households could be regarded as food secure. The binary logistic regression model predictions show that the adoption of CSA ( $p = 0.001$ ) will increase the chances of food security of the sampled households. Household size ( $p = 0.044$ ) and dependency ratio ( $p = 0.074$ ) were found to be statistically significant but negatively correlated with the food security of the sampled farming

households. Farm income ( $p = 0.039$ ), income from off-farm sources ( $p = 0.018$ ), the farming experience of the farmer ( $p = 0.063$ ) and the participation of household members in farming activities ( $p = 0.041$ ) were found to be statistically significant and to positively correlate with the food security status of the sampled households. Gender has no significant effect on the food security status of the sampled households in the combined analysis (KCDM) but has a statistically significant and positive influence on food security in Mthonjaneni.

This study argues that it is imperative to understand the pattern of adoption among small-scale farmers for the successful mainstreaming of CSA related projects and the empowerment of farmers for sustainable agriculture under climate change. The study recommends that relevant stakeholders should endeavor to provide small-scale farmers with CSA-related extension messages and expose them to relevant information on climate change. Farmers have differing preferences for CSA technologies based on the demonstrable potential benefits and cost of the technologies. Therefore, policies aimed at mainstreaming CSA technologies should pay adequate attention to applicability in locations under consideration and emphasize the critical role of information on CSA technologies or practices. This study recommends that efforts are needed to encourage small-scale farmers to embrace CSA practices to enhance productivity and food security.

**Keywords:** Adaptation strategy, adoption, applicability, climate change, climate-smart, food security, mitigation, productivity.

## DECLARATION

I, Victor Oluwadamilare Abegunde (Student No: 201760000), declare that this dissertation entitled *Factors affecting level of use and applicability of Climate-Smart Agriculture practices and implications for food security of small-scale farming households in KwaZulu-Natal Province of South Africa*, ethical clearance UZREC 171110-030 PGD 2018/222, is my work and has been carried out under the joint supervision of Dr Melusi Sibanda of the Department of Agriculture, University of Zululand and Prof Ajuruchukwu Obi of the Department of Agricultural Economics and Extension, University of Fort Hare. I am responsible for the text of this study and all conclusions reached. I have adequately referenced and acknowledged all the resources I used. No part of this thesis has been submitted in the past, or is being submitted, or is to be submitted for a degree at any other university. I have subjected the document to the University's text-matching and similarity checking procedures.

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## **DEDICATION**

I dedicate this work to God, the Almighty and the loving memory of my Father (Mr Segun Adeyemi Abegunde), Grandmother (Mrs Racheal Oyerogun Abegunde) and Grandfather (Rev. Moses Aderoju Abegunde) who were true and vivid representations of selflessness and willingly stretched beyond their comfort zones for the sake of their children.

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## LIST OF PUBLICATIONS AND CONFERENCE PRESENTATIONS

### PUBLICATIONS

1. Abegunde V.O., Sibanda M. and Obi A. (2020). Determinants of the adoption of climate smart agricultural practices by small-scale farming households in King Cetshwayo District Municipality. *Sustainability Vol 12(1)*, 1-27. DOI: 10.3390/su12010195.
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3. Abegunde V.O., Sibanda M. and Obi A. (2019). The dynamics of climate change adaptation in Sub-Saharan Africa: A review of climate-smart agriculture among small-scale farmers. *Climate* 2019, 7(11), 132; <https://doi.org/10.3390/cli7110132>.

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1. Abegunde V.O., Sibanda M. and Obi A. (2018). Factors affecting the adoption of CSA among small-scale farmers in King Cetshwayo District Municipality. *Conference paper accepted for presentation at the 30th World Conference of the International Food and Agribusiness Management Association, Rotterdam, Netherlands. June 15-18, 2020.*
2. Abegunde V.O., Sibanda M. and Obi A. (2018). Factors affecting the adoption of CSA among small-scale farmers in King Cetshwayo District Municipality. *Conference paper accepted for presentation at the 7th International Conference on Food Security and Nutrition, Amsterdam, Netherlands. March 13-15, 2020.*
3. Abegunde V.O., Sibanda M. and Obi A. (2018). The Role of Climate-Smart Agriculture to Small-Scale Farming in ensuring Food Security in South Africa. *Conference paper presented at the 4<sup>th</sup> National Conference on Global Change, Limpopo, South Africa. December 3-6, 2018.*
4. Abegunde V.O., Sibanda M. and Obi A. (2018). Adoption of Climate-smart Agriculture by Small-Scale Farming Households: Towards Food Security and Agricultural Sustainability in Africa. *Presented at the Science Forum 2018, Stellenbosch, South Africa. October 10-12, 2018.*
5. Abegunde, V.O. and Sibanda, M. (2018). Agricultural Sustainability and Food Security in 21<sup>st</sup> Century: A review of Climate-Smart Agriculture in Africa. *Conference paper presented at the 5<sup>th</sup> International Climate Change Adaptation Conference, Cape Town, South Africa. June 18-21, 2018.*

## TABLE OF CONTENTS

ABSTRACT.....	ii
DECLARATION .....	v
DEDICATION.....	vi
ACKNOWLEDGEMENT .....	vii
LIST OF PUBLICATIONS AND CONFERENCE PRESENTATIONS .....	ix
LIST OF TABLES .....	xvi
LIST OF FIGURES .....	xviii
LIST OF ACRONYMS .....	xix
CHAPTER ONE: INTRODUCTION.....	1
1.1 Background to the Study.....	1
1.2 Statement of the Problem.....	4
1.3 Aim and Objectives of the Study .....	6
1.4 Research Questions.....	7
1.5 Significance of the Study .....	7
1.6 Delineation of the Study .....	9
1.7 Organization of the Thesis .....	10
REFERENCES .....	12
CHAPTER TWO: LITERATURE REVIEW .....	17
2.1 Introduction.....	17
2.2 Theoretical Framework .....	17
2.2.1 Theory of Utility .....	17
2.2.2 Theory of Production .....	19
2.2.3 The Food Security Model .....	21
2.3 Empirical Review.....	25
2.3.1 The Concept of Climate Change.....	25
2.3.2 Climate Change Pattern in Sub-Saharan Africa.....	28
2.3.2.1 Change in Temperature.....	29
2.3.2.2 Heat Extremes.....	30
2.3.2.3 Change in Precipitation.....	30
2.3.2.4 Aridity and Evapotranspiration.....	30
2.3.2.5 Rise in Sea Levels.....	31
2.3.3 Overview of Climate Change Trend in Sub-Saharan Africa .....	31
2.3.4 Climate Trends across South Africa .....	32
2.3.5 Perception of Farmers on Climate Change .....	32

2.3.6 Impacts of Climate Change on Agriculture .....	33
2.3.7 Climate Change Impact on South African Agriculture.....	35
2.3.8 The Concept of Adaptation .....	38
2.3.9 Climate Change Adaptation Strategies .....	40
2.3.10 Overview of Climate-Smart Agriculture.....	41
2.3.11 Climate-Smart Agriculture in Sub-Saharan Africa .....	44
2.3.11.1 Climate-Smart Agriculture in Kenya .....	45
2.3.11.2 Climate-Smart Agriculture in Rwanda .....	45
2.3.11.3 Climate-Smart Agriculture in Malawi .....	46
2.3.11.4 Climate-Smart Agriculture in Uganda .....	46
2.3.12 Small-Scale Agriculture in Sub-Saharan Africa .....	46
2.3.13 Farming System in South Africa.....	49
2.4 Analytical Framework .....	49
2.5 Chapter Summary .....	51
REFERENCES .....	53
CHAPTER THREE: RESEARCH METHODOLOGY.....	65
3.1 Introduction.....	65
3.2 Selection and Description of the Study Area .....	65
3.2.1 Geophysical Aspects.....	66
3.2.1.1 Topography .....	67
3.2.1.2 Climate and Rainfall .....	67
3.2.1.3 Temperature .....	67
3.2.1.4 Wind.....	68
3.2.1.5 Vegetation .....	68
3.2.2 Socio-economic Characteristics.....	68
3.2.2.1 Population and Population Density .....	68
3.2.2.2 Educational Levels.....	69
3.2.2.3 Employment Levels .....	69
3.2.2.4 Economic Activities.....	69
3.2.2.5 Agricultural Activities.....	70
3.3 Description of Mthonjaneni Local Municipality.....	70
3.4 Description of uMhlathuze Local Municipality .....	71
3.5 Research Philosophy .....	71
3.6 Research Approach .....	72
3.7 Research Design.....	72

3.8 Conceptual Framework .....	73
3.9 Study Population .....	75
3.9.1 Sample Size and Sampling Techniques .....	76
3.9.2 Data Collection .....	77
3.10 Data Management and Analytical Framework .....	78
3.10.1 Descriptive Statistics.....	78
3.10.2 The Adaptation Strategy Use Index .....	78
3.10.3 The Composite Score .....	78
3.10.4 The Generalized Ordered Logit Regression Model .....	79
3.10.5 The Acceptance Level Index.....	79
3.10.6 The Total Value Product .....	79
3.10.7 The Ordinary Least Squares Regression Model.....	79
3.10.8 Household Dietary Diversity .....	79
3.10.9 Household Food Consumption Score .....	80
3.10.10 The Binary Logistic Regression Model .....	80
3.11 Limitations of the study .....	80
3.12 Ethical considerations .....	81
3.12.1 Rules Compliance .....	81
3.12.2 Informed Consent and Voluntary Participation .....	81
3.12.3 Privacy and Confidentiality .....	81
3.12.4 Language and Cultural Considerations .....	81
3.12.5 Recognition of Local Authorities.....	82
3.12.6 Carefulness.....	82
3.12.7 Integrity.....	82
3.12.8 Honesty .....	82
3.13 Chapter summary .....	82
REFERENCES .....	84
<b>CHAPTER FOUR: THE EXTENT OF THE ADOPTION OF CLIMATE-SMART AGRICULTURAL PRACTICES BY SMALL-SCALE FARMING HOUSEHOLDS IN KING CETSHWAYO DISTRICT MUNICIPALITY .....</b>	
4.1 Introduction.....	89
4.2 Materials and Methods.....	91
4.2.1 Study Area .....	91
4.2.2 Research Design.....	91
4.2.3 Sampling Technique and Data Collection.....	92

4.2.4 Data Analysis .....	93
4.3 Results.....	94
4.3.1 Agricultural Production Activities of Respondents .....	94
4.3.2 Level of Adoption of Climate-Smart Agricultural Practices by Crop Farmers .....	94
4.3.3 Level of Adoption of Climate-Smart Agricultural Practices by Livestock Farmers.....	98
4.3.4 Level of Adoption of Climate-Smart Agricultural Practices adopted by Farmers Engaged in both Crop and Livestock Production .....	101
4.4 Discussion.....	106
4.5 Conclusion and policy implications.....	108
REFERENCES .....	110
CHAPTER FIVE: DETERMINANTS OF THE ADOPTION OF CLIMATE-SMART AGRICULTURE PRACTICES BY SMALL-SCALE FARMING HOUSEHOLDS IN KING CETSHWAYO DISTRICT MUNICIPALITY .....	
5.1 Introduction.....	114
5.2 Materials and Methods.....	115
5.2.1 Study Area .....	115
5.2.2 Research Design.....	116
5.2.3 Sampling Technique and Data Collection.....	116
5.2.4 Data Analysis .....	116
5.3 Results.....	121
5.3.1 Socio-Economic Characteristics of Respondents.....	121
5.3.2 Category of Respondents based on the Level of use of Climate-Smart Agricultural Practices .....	124
5.3.3 Factors Influencing the Level of Adoption of Climate-Smart Agricultural Practices .....	125
5.4 Discussion.....	133
5.5 Conclusion and Policy Implications .....	138
REFERENCES .....	141
CHAPTER SIX: ASSESSING THE APPLICABILITY OF CSA ADOPTION IN THE SMALL-SCALE FARMING SYSTEM OF KING CETSHWAYO DISTRICT MUNICIPALITY .....	
6.1 Introduction.....	146
6.2 Materials and Methods.....	147
6.2.1 Study Area .....	147
6.2.2 Research Design.....	147
6.2.3 Sampling Technique and Data Collection.....	149
6.2.4 Data Analysis .....	149
6.3 Results.....	150

6.3.1 Farmers' Perception of the Social Compatibility of CSA Practices .....	150
6.3.2 Farmers' Perception of Technical Compatibility of CSA Practices .....	153
6.3.3 Farmers' Perception of Economic Compatibility of CSA Practices .....	155
6.3.4 Farmers' Perception of the Environmental Compatibility of CSA Practices.....	157
6.4 Discussion .....	159
6.5 Conclusion and policy implications .....	161
REFERENCES .....	163
<b>CHAPTER SEVEN: THE EFFECT OF CLIMATE-SMART AGRICULTURE ADOPTION ON THE PRODUCTIVITY OF SMALL-SCALE FARMING SYSTEMS: EVIDENCE FROM FARMING HOUSEHOLDS IN KING CETSHWAYO DISTRICT MUNICIPALITY .....</b>	<b>165</b>
7.1 Introduction.....	166
7.2 Materials and Methods.....	167
7.2.1 Study Area .....	167
7.2.2 Research Design.....	167
7.2.3 Sampling Technique and Data Collection.....	168
7.2.4 Data Analysis .....	168
7.3 Results.....	171
7.3.1 Distribution of Respondents by the Total Value Product .....	172
7.3.1 Effect of CSA adoption on the Agricultural Productivity of Respondents .....	172
7.4 Discussion .....	177
7.5 Conclusion and policy implications .....	180
REFERENCES .....	183
<b>CHAPTER EIGHT: THE EFFECT OF CLIMATE-SMART AGRICULTURE ADOPTION ON HOUSEHOLD FOOD SECURITY IN SMALL-SCALE PRODUCTION SYSTEMS: EVIDENCE FROM KING CETSHWAYO DISTRICT MUNICIPALITY .....</b>	<b>186</b>
8.1 Introduction.....	187
8.2 Materials and Methods.....	190
8.2.1 Study Area .....	190
8.2.2 Research Design.....	190
8.2.3 Sampling Technique and Data Collection.....	191
8.2.4 Data Analysis .....	191
8.2.4.1 Household Dietary Diversity .....	191
8.2.4.2 Household Food Consumption.....	193
8.2.4.3 Binary Logistic Regression Model.....	194
8.3 Results.....	196
8.3.1 Result on Household Dietary Diversity .....	196

8.3.2 Food Group Consumption Pattern .....	198
8.3.3 Result on Household Food Consumption .....	200
8.3.4 Result on the Effect of CSA adoption on Food Security .....	200
8.4 Discussion .....	204
8.5 Conclusion and Policy Implications .....	207
REFERENCES .....	211
CHAPTER NINE: SUMMARY, CONCLUSION AND RECOMMENDATIONS .....	215
9.1 Introduction.....	215
9.2 Summary .....	215
9.2.1 Findings from Literature .....	216
9.2.2 A Summary of the Primary Findings .....	219
9.3 Conclusion .....	221
9.4 Recommendations.....	223
9.5 Further research .....	225
REFERENCES .....	227
APPENDIX I: QUESTIONNAIRE .....	230
APPENDIX II: ETHICAL CLEARANCE CERTIFICATE.....	240

## LIST OF TABLES

Table 2. 1: Aspects of Climate Change and Perceived Implications.....	27
Table 2. 2: Impacts of selected Climate Models on Net Revenues (US \$/ha).....	37
Table 2. 3: Change in revenue from crop and livestock production (US \$/farm) .....	38
Table 4. 1: Distribution of Sampled Farmers based on their Agricultural Production Activity .....	94
Table 4. 2: Ranked Order of Climate-Smart Agricultural Practices Adopted by Sampled Small-Scale Crop Farmers .....	96
Table 4. 3: Ranked Order of Climate-Smart Agricultural Practices Adopted by the Sampled Livestock Farmers.....	100
Table 4. 4: Ranked Order of Climate-Smart Agricultural Practices Adopted by Sampled Small-Scale Farmers Engaged in both Crop and Livestock Production.....	102
Table 5. 1: Explanatory variables in the logit model used for the analysis of the determinants of the level of CSA adoption and their expected outcomes .....	118
Table 5. 2: Socio-Economic Characteristics (continuous variables) of the sampled Farmers .....	121
Table 5. 3: Socio-Economic Characteristics (categorical variables) of the sampled Farmers .....	123
Table 5. 4: Categories of respondents by their level of use of Climate-Smart Agricultural Practices .....	124
Table 5. 5: Likelihood-Ratio Test of Proportionality of Odds.....	126
Table 5. 6: Brant Test of Parallel Regression Assumption.....	127
Table 5. 7: Results of the factors influencing the level of adoption of CSA practices by the respondents .....	129
Table 6. 1: Farmers' Perception on Social Compatibility of Climate-Smart Agricultural Practices .....	152
Table 6. 2: Farmers' Perception of Technical Compatibility of Climate-Smart Agricultural Practices .....	154
Table 6. 3: Farmers' Perception of Economic Compatibility of Climate-Smart Agricultural Practices .....	156
Table 6. 4: Farmers' Perception of Environmental Compatibility of Climate-Smart Agricultural Practices.....	158
Table 7. 1: Explanatory variables in the OLS regression model .....	169

Table 7. 2: Distribution of TVP among the sampled farmers (ZAR) .....	172
Table 7. 3: Effect of the level of CSA Adoption on the productivity of the sampled small-scale farmers .....	173
Table 8. 1: Categories of Food Groups .....	192
Table 8. 2: Weight attached to Food Groups .....	194
Table 8. 3: Categories of the Sampled farmers based on Dietary Diversity Score.....	196
Table 8. 4: Categories of the Sampled Farming Households with respect to Food Security	197
Table 8. 5: Categorization of the Sampled Households based on Household Food Consumption Score.....	200
Table 8. 6: Effect of CSA Adoption on the food security status of sampled farming households.....	201

## LIST OF FIGURES

Figure 2. 1: Best practices, potential absolute frontier and measure of inefficiency .....	20
Figure 2. 2: Framework of Food Security .....	23
Figure 3. 1: Map showing KCDM and its local municipalities .....	66
Figure 3. 2: Research design followed for the study .....	73
Figure 3. 3: Conceptual framework – The influence of CSA on agricultural productivity and food security.....	74
Figure 4. 1: Conceptual framework – Adoption of CSA practices among small-scale farmers .....	92
Figure 6. 1: Conceptual framework – Location-Specific Assessment Concept .....	148
Figure 7. 1: Conceptual framework – Influence of CSA adoption on agricultural productivity .....	168
Figure 8. 1: Conceptual framework – Influence of CSA adoption on agricultural productivity .....	190
Figure 8. 2: Food Group Consumption Pattern in Mthonjaneni, uMhlathuze and KCDM ...	199

## LIST OF ACRONYMS

ALI – Acceptance Level Index

ASUI – Adaptation Strategy Use Index

CA – Category of Acceptance

CCC – Canadian Climatic Centre

CCSR – Centre for Climate Systems Research

CSA – Climate-Smart Agriculture

DARD – Department of Agriculture and Rural Development

DEA – Department of Environmental Affairs

FAO – Food and Agriculture Organization of the United Nations

FGD – Focus Group Discussion

FU – Frequently Used

GDP – Gross Domestic Product

GOLOGIT – Generalized Ordered Logit Regression

HDDS – Household Dietary Diversity Score

HFCS – Household Food Consumption Score

IASTD – International Assessment of Agricultural Knowledge, Science, and Technology for  
Development

IPCC – Intergovernmental Panel on Climate Change

KCDM – King Cetshwayo District Municipality

KZN – KwaZulu-Natal

NASAC – Network of African Science Academics

NRF – National Research Foundation

NU – Never Used

OLS – Ordinary Least Squares

OU – Occasionally Used

PCM – Parallel Climatic Model

RU – Rarely Used

SPSS – Statistical Package for Social Science

TVP – Total Value Product

TWAS – The World Academy of Science

UNDESA – United Nations Department of Economic and Social Affairs

UNFCCC – United Nations Framework Convention on Climate Change

WHO – World Health Organization

ZAR – South African Rand

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background to the Study

Agriculture in the 21<sup>st</sup> century faces a lot of challenges, not least of which is the need for increased food production to meet the ever-growing global population as well as more feedstock to cater for a potentially large bioenergy market (Mugi-Ngenga *et al.*, 2016; World Bank, 2016). Agriculture remains crucial for the overall development of countries and the need for efficiency and sustainability in production, especially in the context of adaptation to climate change has become very compelling (Ziervogel *et al.*, 2014). The growing global population makes all these challenges more demanding, placing significant pressure on the sector (Food and Agricultural Organisation of the United Nations, FAO, 2009; 2014).

The current global population is estimated at 7.8 billion in 2020 and projected to reach 8.5 billion in 2030 and 9.7 billion in 2050 (Barro *et al.*, 2020). The projection represents a population growth of more than 30 per cent between 2009 and 2050, and about 10 billion by the close of the century (FAO, 2014; Barro *et al.*, 2020). Africa hosts about 1.2 billion people and accounts for the highest proportion of people battling with undernourishment (UNDESA, 2016). South Africa as a country has about 28 per cent of its population living below the poverty line (Statistics South Africa, 2017). Two of the most significant tasks facing most developing countries are ensuring food security and alleviating poverty. The World Health Organization, WHO (2013), defines a country as being food secure when nutritious and healthy food is sufficient at all times. What determines food security include availability, accessibility, stability and utility (FAO, 2015).

The challenge of massive food demand posed by the growing population already deserves serious attention, but it is being worsened by changes in climatic conditions (Vermeulen, 2014). The Action Plan for African Agricultural Transformation, a platform of African leaders in partnership with the World Bank, states that there is a need for agricultural transformation in African countries in the coming years (Williams *et al.*, 2015). The transformation is needed if the twin challenges of food insecurity and poverty will be abated and the threat posed by changes in climatic conditions to agricultural production will be tackled without depleting the natural resources base (Williams *et al.*, 2015).

Climate change has complicated the challenges faced in the fight against food insecurity, poverty and agricultural sustainability in many African countries (Mutoko *et al.*, 2015). Studies have predicted climate change would adversely influence farm production in the sub-Saharan region through a decline in crop yields and livestock productivity due to increased temperatures, varying rainfall patterns and increase in pest or disease incidence (Descheemaeker *et al.*, 2016; Ayanlade *et al.*, 2018; Alemu & Mengistu, 2019).

There is evidence of a higher likelihood of negative influence of changes in climatic conditions in developing nations when compared with the developed nations (Mutoko *et al.*, 2015). Despite the evidence, there is more effort in quantifying the impact brought about by changes in climatic condition on developing nations than the developed countries (Vermeulen, 2014). The susceptibility of the agricultural sector to climatic change is alarming and has drawn the attention of policymakers in African countries due to the sensitive and critical position agriculture holds in their economies.

Despite the low contribution of the agricultural sector to the South African GDP, when compared with other sectors, it remains a significant sector. It plays the crucial role of job creation and serves as source of foreign exchange (about 4.6% of the labor force are employed in the agricultural sector) It also has a prominent indirect role of backward and forward linkages with other sectors; about 70 per cent of outputs from agricultural production are used as either raw materials or intermediate products (Greyling, 2015). The extent to which climate change affects agricultural productivity in developing countries including South Africa remains a subject of interest, given the significance of the agricultural sector in many developing countries (Pillay, 2016).

A great deal of attention has been drawn towards developing means and methods to sustain agricultural activities in Africa by promoting the adoption of Climate-Smart Agriculture (CSA) among farmers for improved productivity (Dooley & Chapman, 2014). The FAO came up with the approach called CSA, which is designed for the enhancement of policy, technical and investment conditions to attain agricultural sustainability towards ensuring food security under climate variability. The concept of CSA emerged in 2010 after the Hague conference, where countries discussed the adverse impact of climate change and how to go about mitigating its effects. The meeting resulted in a list of actions and policies which are to be implemented to realize its goals (FAO, 2015).

The adoption of CSA is considered an efficient way of improving agricultural productivity in the face of changes in climatic condition (Kitsao, 2016). This is because of the “triple win effect” benefits that it has to offer. The triple win effect is expressed as reduction of gas emissions, increase in production and increase in adaptation to climate variability particularly in countries that are highly agriculture dependent (Kitsao, 2016). Climate-Smart Agriculture aims to address food insecurity alleviated by climate change by enhancing resilient and sustainable systems to increase food production (FAO *et al.*, 2014). It aims at improving the capacity of farmers to adapt to climate-related shocks through efficient resource use and the creation of an agricultural system that can withstand changing climatic conditions (Lipper *et al.*, 2014). A farm household adopting CSA will be better off than those who do not and this is because CSA integrates adaptation, food security and mitigation benefits (Dooley & Chapman, 2014).

A report by FAO (2016) reveals that more than 60 per cent of the world’s population depend on agriculture for survival, either as full-time or part-time farmers, at individual or household level. However, beyond the significance of the whole agricultural sector, is the critical need to pay attention to small-scale agriculture. Fields (2011) highlighted the importance of small-scale agriculture in most developing nations. According to Gollin (2014), the majority of the farming households in Sub-Saharan Africa rely on small-scale agriculture for livelihood. In turn, agriculture in most African countries is dominated by small-scale farmers (African Centre for Biodiversity, 2017). Considering the role small-scale agriculture plays, it is identified as a significant driving force of agricultural and rural development in Africa (Gollin, 2014).

Small-scale agriculture is a critical player in providing food and employment in South Africa, just like in other Sub-Sahara African countries. According to Qwabe (2014), about 1.3 million households in South Africa engage in small-scale farming, and small-scale agriculture accounts for about 17 million hectares of land under cultivation in the country. By 2014, 20.7 per cent of the households in South Africa had already involved themselves in agriculture, and 65 per cent of these farming households were on small-scale farms (Republic of South Africa, 2014).

However, along with the potential of the small-scale farming system is the challenge of the vulnerability to climatic change and variability. Climate change and variability have placed strain on land and water resources, especially where small-scale farmers are dependent on for farming activities, thereby affecting their production (Pillay, 2016). A report by FAO (2016) revealed that extreme weather conditions had facilitated much damage to crop production on

small-scale farms in South Africa. According to the report by FAO (2016), 226 583 small-scale farms were affected by the scourge of drought. As a result, looking into the problem of climate change as it concerns small-scale agriculture has a high potential of influencing food security and agricultural productivity in African countries because of the critical position it occupies in the agricultural sector.

## **1.2 Statement of the Problem**

About 48 per cent of Africa's population is poor, with 63 per cent of the indigent population relying on agriculture for their livelihood World Bank (2015). South Africa is one of the countries with a high rate of income inequality and poverty level in the world (Statistics South Africa, 2014). South Africa's Gini coefficient is estimated at 0.68 (Statistics South Africa, 2017). Complicating the challenge of poverty is the exploding population and urbanization taking place in South Africa and the continent. About 56 per cent of South Africa's population live in poverty, while almost 28 per cent live below the food poverty line (Statistics South Africa, 2017). As earlier stated, there is the need to scale up food supplies to be able to combat food insecurity (FAO *et al.*, 2014).

There is a need for increased capacity for food supply if future demand for food will be met. However, with this task at hand, the ecosystem needed for this venture is deteriorating. Farmers in African countries are feeling the impact of climate change, predominantly through changes in the regularity and intensity of precipitation, and in its distribution within a season of growth (Pillay, 2016). For example, South Africa experiences an uneven distribution of rainfall with average annual rainfall of 464mm, which is lower than the global average of 860mm (DEA, 2011). The mean annual temperatures in South Africa have risen above the global average of 0.65°C by at least 1.5 times over the past five decades (Ziervogel *et al.*, 2014). Because of this, agriculture in South Africa cannot continue in a business-as-usual manner and must undergo a dynamic change. Based on past studies, it has become apparent that substantial progress in agriculture is the best approach for poverty reduction and food security in African countries (Wiggins & Keats, 2013; Gollin, 2014). As a result, there is a need for a rapid transformation in the agricultural sector in Africa for improved food security for the increasing populace and a solid basis for poverty alleviation and economic growth and development.

The issue of climate change has aroused increased public debate and political interest in the last two decades. To date, adaptation and mitigation policies are the climate protection strategies proposed to handle the issue of climate change globally. Accordingly, there is an

ever-increasing global interest on the impact of climate on farming, farmers' vulnerability to the challenge of change in climatic condition and the role of adaptation programming at the farm level (Williams *et al.*, 2015). However, there is still sparse empirical knowledge on the capacity of farmers to adjust and adapt adequately and the resultant effect on agricultural productivity and food security.

Even with the complications caused by climate change, small-scale farmers are expected to still play a crucial role in agriculture, especially in African countries (Wiggins & Keats, 2013; Descheemaeker *et al.*, 2016). The difficulties from climate change is exacerbating the growing phenomenon of de-agrarianization; many small-scale farmers in South Africa, for example, are faced with the challenge of low productivity and could not produce more than a marginal surplus, thereby getting discouraged and leaving agriculture (Mtero, 2014) Rural youth are massively moving away from agriculture and rural communities (White, 2012; Leavy & Hossain, 2014).

Many small-scale farmers or households using crude farm tools with limited farm energy and labor constraints are marginalized and struggling in production (Tshuma, 2014). Climate change, of a very high likelihood, will increase the possibility of food insecurity for those in this category. Better opportunities exist for small-scale farmers in agricultural intensification and effective adaptation to climate change (Tshuma, 2014; Wiggins & Keats, 2015).

However, according to FAO (2013), CSA was launched to assist farmers in adapting to changing climatic conditions, and alleviate the probable adverse effect on their production and livelihood. There are submissions that CSA adoption in African context will bring about improvement in indigenous or traditional systems of agriculture and also boost the practice of agro-ecological agricultural systems thereby resulting in increased productivity (Dooley & Chapman, 2014; Wekesa *et al.*, 2018). There is, however, no empirical backing for this assertion yet and there are few studies in its support. Establishing the potential applicability and impact of CSA in the context of African societies is highly essential for a full embrace by farmers and for the enhancement of the political will needed to stimulate profound revolutions required within the policy sector.

Although many countries are expected to adopt CSA in handling the ordeal of climate change, how it can be applied in African countries is unclear, understudied and there has been no assessment of its sustainability (Fanen & Olalekan, 2014). Besides, many small-scale farmers do not have the financial and technical capacity needed to adopt or sustain some agricultural

practices or innovations, unlike the commercial farmers who are comfortable in that respect. There is, therefore, the need to assess how applicable the concept of CSA is among different recommendations. It is a common experience for various ideas to be recommended as a panacea, only to discover that such views are not suitable in many contexts, particularly in developing countries after they might have committed their scarce resources to adopt them. Having raised this, CSA has been adopted with encouraging results in certain African countries like Burkina Faso, northern Cameroon; and the Nile Delta, Egypt (Terdo & Adekola, 2014).

Farmers may be adapting to changing climatic conditions; however there is low adoption of potentially beneficial practices in many other African countries (McCarthy *et al.*, 2011; Arslan *et al.*, 2014). This informs the need for detailed studies that will enhance the understanding of the applicability of CSA in the context of different ecological and agricultural systems. This will help to conceptualize what climate-smartness is in different biophysical and socio-economic contexts (Lipper *et al.*, 2014). There is, however, a dearth of studies on the assessment of the potential of the CSA approach in South Africa, a country that has one of the most productive and sophisticated agricultural sectors and economies in Africa.

The assessment of CSA in South African agriculture is essential as the information generated will be useful in adding to the knowledge base and also providing information on the potential of CSA and the determinants of CSA adoption in the small-scale farming system in an African context. To this end, this study investigates the CSA practices the farmers are using and further asks the fundamental questions: (1) What factors influence the adoption of CSA and to what extent is the applicability of the CSA practices? (2) What is the effect of CSA adoption on agricultural productivity and farming household food security? The appraisal of the factors influencing the level of acceptance and applicability of CSA practices is critical as the adoption may not be automatic. The second question is impact-driven as the focus is on the outcome of CSA adoption on productivity and food security.

### **1.3 Aim and Objectives of the Study**

The study aims to determine the effect of CSA practices on the food security status of small-scale farming households in KCDM of the KZN Province of South Africa.

The specific objectives are to:

1. Describe the extent of adoption of CSA practices by small-scale farming households in the study area/ s.

2. Determine the factors influencing the level of adoption of CSA practices by small-scale farming households in the study area/ s.
3. Assess the level of applicability of the CSA practices in the small-scale farming system in the study area/ s.
4. Examine the effect of the adoption of CSA practices on the productivity of small-scale farming households in the study area/ s.
5. Examine the effect of CSA practices on the food security status of the small-scale farming households in the study area/ s.

#### **1.4 Research Questions**

Given the massive threat of climate change and its negative impact on food security, this study seeks to address some of the issues as mentioned earlier by providing answers to the following central research question:

What is the effect of CSA on food security of small-scale farming households in KCDM of the KZN Province?

The sub-research questions are:

1. What are the various CSA practices adopted by small-scale farming households in the study area/ s?
2. What are the factors influencing the adoption of CSA practices by the small-scale farming households in the study area/ s?
3. What is the level of applicability of the CSA practices in the small-scale farming system in the study area/ s?
4. What are the effects of adopting CSA practices on the productivity of small-scale farming households in the study area/ s?
5. What is the effect of adopting CSA practices on the food security status of small-scale farming households in the study area/ s?

#### **1.5 Significance of the Study**

Several studies have shown how climate variability affects the agro-environmental system and agricultural production. Such studies include the impact of climate change on agro-ecological zones in Africa, effects of climate change on water availability for crop production and effects of climate change on yield and food production (Calzadilla *et al.*, 2014; Field, 2014; Tarchiani

*et al.*, 2017). However, there is a dearth of studies on farmers' adaptation to climate change. Most of the available studies focused on a particular adaptation strategy concerning climate change. Many of the adaptation strategies may help farmers in adapting to climate change but may not be efficient in climate change mitigation.

This study is, however, interested in a more holistic approach regarding changes in climate conditions. The concept of CSA is conceptualized as an approach to respond to climate variability on a global level since it does not deal with mitigation or adaptation benefits in isolation (FAO, 2013). Within the CSA framework lies the potential for integrating the benefits of adapting to changes in climatic conditions, reducing GHG emissions, and improving food security (Wollenberg *et al.*, 2012; Lipper *et al.*, 2014). Therefore, CSA might be the right approach to integrate programs aimed at addressing agricultural development and climate change (Neufeldt *et al.*, 2013; Terdoo & Adekola, 2014). The location where CSA is to be adopted needs to be considered when the decision on adoption is to be made. This is what makes it suitable to the location where it is being adopted. This study therefore assesses the state of climate change adaptation and mitigation in the agricultural system in the province of KwaZulu-Natal of South Africa by focusing on the CSA adoption level and its determinants. The study probes into the effects of CSA on agricultural productivity and food security.

In terms of contribution to knowledge and novelty, this study does not only investigate the adoption of CSA and its effect (which has been the approach of past studies on CSA), it also investigates the level of adoption and applicability of CSA practices. It explores the levels of capacity, vulnerability and uniqueness of production by small-scale farmers. Furthermore, attention will not only be given to factors influencing CSA adoption but also those responsible for the differences in the level of use of CSA practices. The study also deviates from the conventional approach of focusing on the characteristics of farmers to examine the inherent aspects of CSA practices which could determine the applicability of the practices and therefore could be of significant influence on adoption. This study addresses the applicability of CSA practices via four parameters – social compatibility, technical compatibility, economic compatibility and environmental compatibility.

This study provides insight and information on holistic climate-smart interventions that are location-specific and can be applicable for similar terrains. Findings from the study will enhance the future adoption of CSA and provide guidelines on implementing ideas on agricultural emissions reduction based on experience and best practices. The main goal is

increased effort towards mitigating the effects of climate change on agriculture coupled with the enhancement of agricultural productivity in the bid to achieving food security.

South Africa is without any doubt vulnerable to climate variability as agricultural activities depend significantly on the quality of rain patterns. South Africa experiences climate change more than most of the other countries because of the enormous ocean bodies almost surrounding it and its long coastline stretching more than 3000km (Obi *et al.*, 2018). As a result, increased temperatures, erratic rainfall and reduction in water availability predicted to arise due to change in climatic conditions could significantly lead to a decrease in productivity levels. Also, changes in climatic conditions pose significant threat to the prevalence and intensity of natural disasters resulting in substantial crop loss (Tibesigwa & Visser, 2015). Given the probable negative influence of a changing climate on agricultural productivity, CSA stands to benefit the South African agricultural sector. Efforts to introduce CSA practices could be utilized in targeting where the country's agricultural sector is vulnerable (Mnkeni & Mutengwa, 2014; Mathews *et al.*, 2018).

Based on the foregoing, there is the need to study the concept of CSA as a response to climate change challenges at the farm household (micro) level. The lack of locally based studies makes it difficult to have a clear context-specific picture of the situation, and this is what this study will be doing by providing empirical evidence from farming households in South Africa. This information will be valuable to policymakers, researchers and academics. In terms of policy making, an understanding of farmers' perception of the changes in climatic conditions, adaptation strategies (CSA practices) and their effects on the food security of farming households will facilitate the effective development of programs that will strengthen farmers' resilience based on community-driven approaches. It will also provide sustainable policy solutions to boost productivity in agriculture and food security in the country.

### **1.6 Delineation of the Study**

This study sets out to examine CSA potential in the small-scale agricultural sector with regards to productivity and food security. Given the broad scope of CSA, agricultural productivity and food security, it is imperative to iterate the full scope of the study exhaustively. In achieving the aim and objectives of this study, it is essential to state that this study identified agricultural practices that fit into the profile of CSA as analyzed by FAO. This is not an empirical study of CSA programs by governments or any organization. Rather, its primary focus is to investigate

how the adoption of agricultural practices that are climate-smart influences the agricultural productivity and food security of small-scale households.

This study does not focus on the dynamics of agricultural productivity and food security but on the role of CSA adoption. As part of its objectives, the study includes an analysis of the food security status of small-scale farming households in the study area. The food security status of the households is measured using the household dietary diversity score (HDDS), with household food consumption score (HFCS) as a supplementary approach. However, the analysis of the effect of CSA adoption on food security is limited to the use of HDDS as proxy for food security measure. Given time and resources limitations, the study is limited to a lower level analysis (at household level) especially with regards to rural areas. The results may not be extended to the urban sector and therefore, may not be generalized at the macro level.

### **1.7 Organization of the Thesis**

This thesis is written in a scientific publication format and the repetition of some information is thus unavoidable. The thesis (argument) is therefore structured into nine chapters for a smooth flow of reporting and compartmentalization. Some chapters such as literature review have information that are common to all chapters. These components are dealt with exhaustively in the respective chapters while they are summarized in the manuscript chapters, with sufficient cross-referencing wherever needed.

### **Chapter 2: Literature Review**

This chapter presents an overview of the theoretical framework underpinning this study, and the reviews of literature which are relevant to this study in terms of policies, related empirical works and methodologies.

### **Chapter 3: Methodology**

This chapter presents information on the study area, the research approach and analytical methods.

### **Chapter 4 – 8: Results and Discussion**

These chapters present and discuss the results from the analysis of the objectives of this study. Each is written in the form of a separate publication with each chapter addressing each objective of the study. As such, there is a degree of overlapping information in these chapters.

## **Chapter 9: Summary, Conclusion and Recommendations**

This chapter presents the general summary, conclusions and recommendations based on the findings from the study. Further suggestions for future studies are also presented in this chapter.

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## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter presents an overview of knowledge and evidence emanating from previous studies relating to climate change, CSA adoption and its effect on food security in the small-scale agricultural system in Africa and South Africa as a country. The chapter is divided into three main sections namely, the theoretical framework, the empirical review and the analytical framework. The theoretical framework highlights the theories underpinning this study, the empirical review highlights findings of past studies on climate change and the effect of CSA on the agricultural system, while the analytical framework highlights the analytical approaches employed by previous studies in investigating the effect of CSA on food security.

#### **2.2 Theoretical Framework**

This section presents theoretical explanations for the relationship between the adoption of practices and adaptation behavior, agricultural productivity and household food security. The theoretical framework of the study establishes causal relationships between the focal components of the study. This section also presents theoretical guidance in substantiating the results from the analysis of the data collected. The study rests on three underlying theoretical concepts namely, the theory of utility, the theory of production and the food security model. Through a review of these theories, this section explores choice and preference, the basic components of food security and the efficiency of production.

##### **2.2.1 Theory of Utility**

The theory of utility as it relates to consumer preferences has been recognized as the only way to explain preferences. The theory of utility explains the behavior of individuals on the basis that individuals can consistently rank their choices based on their preferences (Baumol & Blinder, 2015). With the theory of utility, what is deemed necessary about utility concerning choice/ s being made is whether an option has a higher utility than another and not the measure of the difference between the available options. The preferences of a consumer are the basic descriptions employed for choice analysis, and utility is a way of describing consumers' preferences (Varian, 2014; Baumol & Blinder, 2015). The only significant feature of utility is how available choices are ordered. Based on the theory of utility, the magnitude of the utility

function is dependent upon the extent or degree the choices are ranked. The size of the difference in the utility of the options available does not matter. This kind of utility is called ordinal utility due to the emphasis placed on the ordering of choices (Varian, 2014). The consideration of choices made on which agricultural practices to be adopted by farmers hangs on the concept of ordering available options based on the benefits they stand to get from the practices.

According to Terdoo and Adekola (2014), deciding whether or not to adopt any CSA practice falls under utility and profit maximization theoretical framework. There is the assumption that economic agents, including small-scale farmers, adopt CSA practices when the expected utility or net benefit is significantly higher than when they do not adopt. As utility cannot be directly observed, the activities of economic agents could be observed through their choices. We will consider a rational farmer whose aim is maximizing proceeds from production over a specific period and has a set of CSA practice  $j$  options to choose from. The farmer  $i$  decides to adopt CSA practice  $j$  if the utility from  $j$  is perceived to be more than that from other options (assume,  $k$ ). This relationship is expressed as (equation 1):

$$U_{ij} = (\beta_j' X_i + \varepsilon_j) > U_{ik} = (\beta_k' X_i + \varepsilon_k), k \neq j \quad (1)$$

Where;

$U_{ij}$  and  $U_{ik}$  denote the perceived utility by farmer  $i$  from CSA practice options  $j$  and  $k$ , respectively;

$X_i$  is a vector of regressors that influence CSA practice option the farmer chooses;

$\beta_j$  and  $\beta_k$  are parameters of the predictor variables;

$\varepsilon_j$  and  $\varepsilon_k$  are the error terms, which based on an econometric assumption are independently and identically distributed.

Under the preference assumption that the farmer decides to adopt a CSA practice option which is more beneficial or generates net benefits and does not adopt a different practice, the observable discrete choice of practice can be related to the latent continuous net benefit variable as (equation 2):

$$\begin{aligned} Y_{ij} &= 1 \text{ if } U_{ij} > 0 \text{ and} \\ Y_{ij} &= 0 \text{ if } U_{ij} < 0 \end{aligned} \quad (2)$$

In the generated formula,  $Y$  is a binary dependent variable valued as 1 when the farmer opts for a CSA practice and 0 if otherwise. The probability of farmer  $i$  choosing CSA practice option  $j$  among the set of adaptation options could be expressed as (equation 9):

$$\begin{aligned}
 P(X = 1/X) &= P(U_{ij} > U_{ik} / X) & (3) \\
 &= P\left(\beta'_j X_i + \varepsilon_j - \beta'_k X_i - \varepsilon_k > \frac{0}{X}\right) \\
 &= P\left(\beta'_j X_i + \varepsilon_j - \beta'_k X_i - \varepsilon_k > \frac{0}{X}\right) \\
 &= P(\beta^* X_i + \varepsilon^* > 0 / X) = F(\beta^* X_i)
 \end{aligned}$$

Where  $P$  is a probability function,  $\varepsilon^* = \varepsilon_j - \varepsilon_k$  is a random disturbance term,  $\beta^* = (\beta'_j - \beta'_k)$  is a vector of unknown parameters that can be explained as the net influence of the determinants of the choice of CSA practice, and  $F(\beta^* X_i)$  is a cumulative distribution of  $\varepsilon^*$  estimated at  $\beta^* X_i$ . Depending on the distribution of the variables, that the variables follow, several quantitative choice models such as linear probability, logit or probit model could be adopted for estimation (Green, 2012). The logit and probit models are the favorites in the literature. Both models have required statistical features, as the probabilities are between 0 and 1 (Green, 2012).

### 2.2.2 Theory of Production

According to Otitoju (2013), the production process involves the transformation of a set of inputs to an output. Most empirical studies on efficiency and productivity rely on the economic theory of production. Efficiency in production refers to the achievement of production objective/ s with little or no waste. Starting with the concept of “no waste”, economists have formulated different theories on the subject of efficiency. However, the quantity of goods and services per unit input is key to all efficiency measurements. Based on this, the efficiency of a production unit is not determined by output levels alone but also by input/ s used in the process.

There are two basic approaches in estimating efficiency; the frontier approach and the classical approach. The classical approach is also called partial productivity measure, and it measures the ratio of output to a particular input. The shortcomings of this measure led to the formulation of advanced econometric and linear programming methods for analyzing efficiency and productivity. The frontier approach, however, determines the efficiency level of a production

unit by how much it lies above or below the production frontier. Firms operating on the production frontier are regarded as efficient while those operating below are inefficient.

The production function is defined as the technical relationship linking factor inputs with outputs. It explains how the product quantity is dependent on the quantity(-ies) of input utilized (Anyanwu, 2013). The theoretical definition of production function depends on the expression of the highest level of input/ s that can be obtained from a given inputs with fixed technology (Otitoju, 2013). The definition is based on the assumption that technical inefficiency is not present in the production function. The efficiency of production is measured against a frontier. The gap between the actual production and potential production determines the level of technical efficiency of production (Varian, 2014). The level of efficiency depends on the measure of the deviation of the actual output from the optimum production or production frontier. If the production point lies on the frontier, then a perfectly efficient production is achieved but if the production point is below the frontier, there is technical inefficiency in the production. The ratio of the actual production to the potential output defines the level of efficiency in the production system. Figure 2.1 presents the best practices, potential absolute frontier and the measure of inefficiency in production

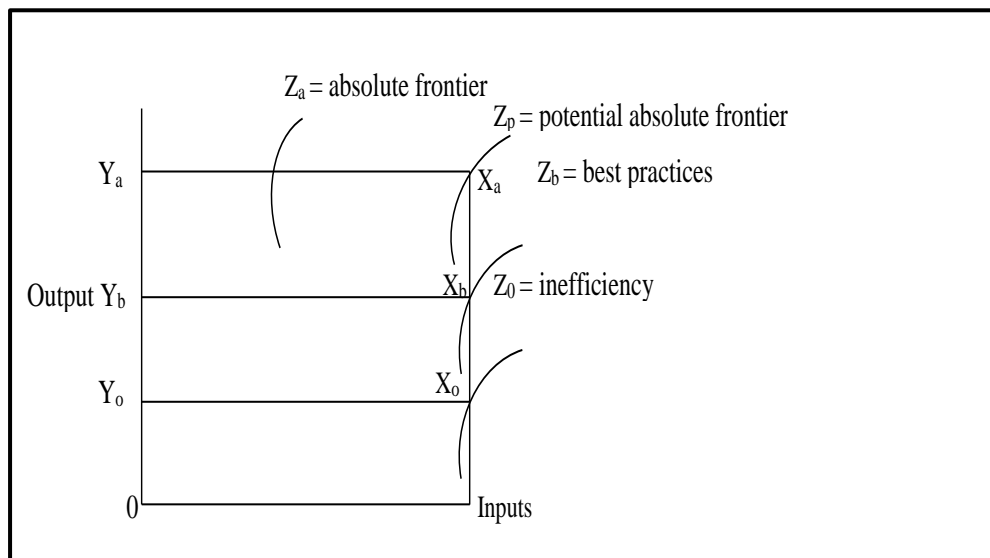


Figure 2. 1: Best practices, potential absolute frontier and measure of inefficiency  
Source: Varian (2014)

In Figure 2.1,  $Y_0/Y_b$  compares the output at  $X_0$  and  $C_b$ , both at the same input level. However,  $X_b$  is on the best practice frontier point  $Z_b$ , while  $X_0$  rests on  $Z_0$ , representing a neutral shift of the frontier  $Z_b$  and passing through  $X_0$ . The absolute potential frontier is denoted by  $Z_p$ , depicting the highest level of output from the technology adopted. In due time, there is an

upward movement of the absolute frontier function  $Q_p$  (Varian, 2014). The production frontier is expressed in three economies of scale namely, constant returns to scale, decreasing returns to scale and increasing returns to scale (Anyanwu, 2013).

### **2.2.3 The Food Security Model**

The World Food Summit describes food security as a state where there is full physical and economic access to sufficient, healthy and nutritious food needed for a lively life (FAO, 1996; 2015). There are four critical components in assessing food security in any system; how available, accessible and sustainable food is, and how well food can be utilized in such a system (Zhou *et al.*, 2017). Availability means there is food in large quantities; accessibility means being able to acquire the required quantity; sustainability means consistency of access and utilization relates to food quantity and quality at sufficient levels. Food availability is dependent on the quantities of food from production, storage, processing, distribution and exchange. According to the FAO (2015), food availability refers to the net amount realized after deducting food exports from the sum of production, stocks and imports. The assessment of whether a nutrient is adequate or not is carried out by comparing the available average nutrient estimate per person per day with the required nutrient estimate. Food availability deals with food sufficiency and with the capacity of the agricultural system to meet food demand. It is determined by the agro-climatic fundamentals of crops and pasture and the whole range of socio-economic and cultural factors that influence farmers' response to markets (Zhou *et al.*, 2017).

Access to food is closely linked with the resources needed for food procurement, implying that access to food is influenced by income (Mbukwa, 2013). Food accessibility is a function of the ability to secure the resources – legal, political, economic or social – required to get access to food (FAO, 2015). This includes being able to access the resources needed for the acquisition of food necessary for a proper diet. Today, the notion of food security applies to both individual and household levels as against what obtained before the 1970s when it was limited to national food production and world trade (FAO, 2015).

Food stability is influenced by the temporal or permanent nature of access to the resources required for sufficient food consumption (FAO, 2015). Variability in climatic conditions is a significant determinant of unstable access to food. The predicted escalation in weather fluctuation will likely exacerbate food insecurity to a critical level where food systems at the local or global scale are not guaranteed (FAO, 2015). Food utilization refers to the absorption

of vital nutrients from the food consumed as well as the safety and nutritional value of the diet. It also relates to factors such as the social values of foods, the quality and safety of food supply all of which influence the food consumed on different occasions and at different periods (FAO *et al.*, 2013; FAO, 2015).

According to FAO *et al.* (2013), food security goes beyond physical and economic access and includes social access to food. Food has to be safe, nutritious and sufficient with the expected outcome of meeting dietary needs for a healthy life. Food security is influenced by several natural, political and socio-economic factors such as government policies, land area under cultivation, age, education, income, availability of infrastructure and extension services (Zhou *et al.*, 2017). According to Oni *et al.* (2011), Msangi (2014) and Ngema *et al.* (2018), factors determining food security include the size of the household, the economic standing of household, income level, quality of household human capital, access to social capital, consumer price variability and food storage and inventory.

The way food security has been viewed has changed over time. There are diverse definitions of food security now, and they are informed by which theory is adopted for assessment and farm measurement. The food security model chosen for this study is adapted from the production and consumption behaviors of rural households. The measure of utility is derived from food consumption through satisfaction in taste characteristics and health effect/ s of the food consumed by households (FAO, 2015). Figure 2.2 shows the framework for food security, highlighting the link between the components of food security and the interconnection with some influencing factors.

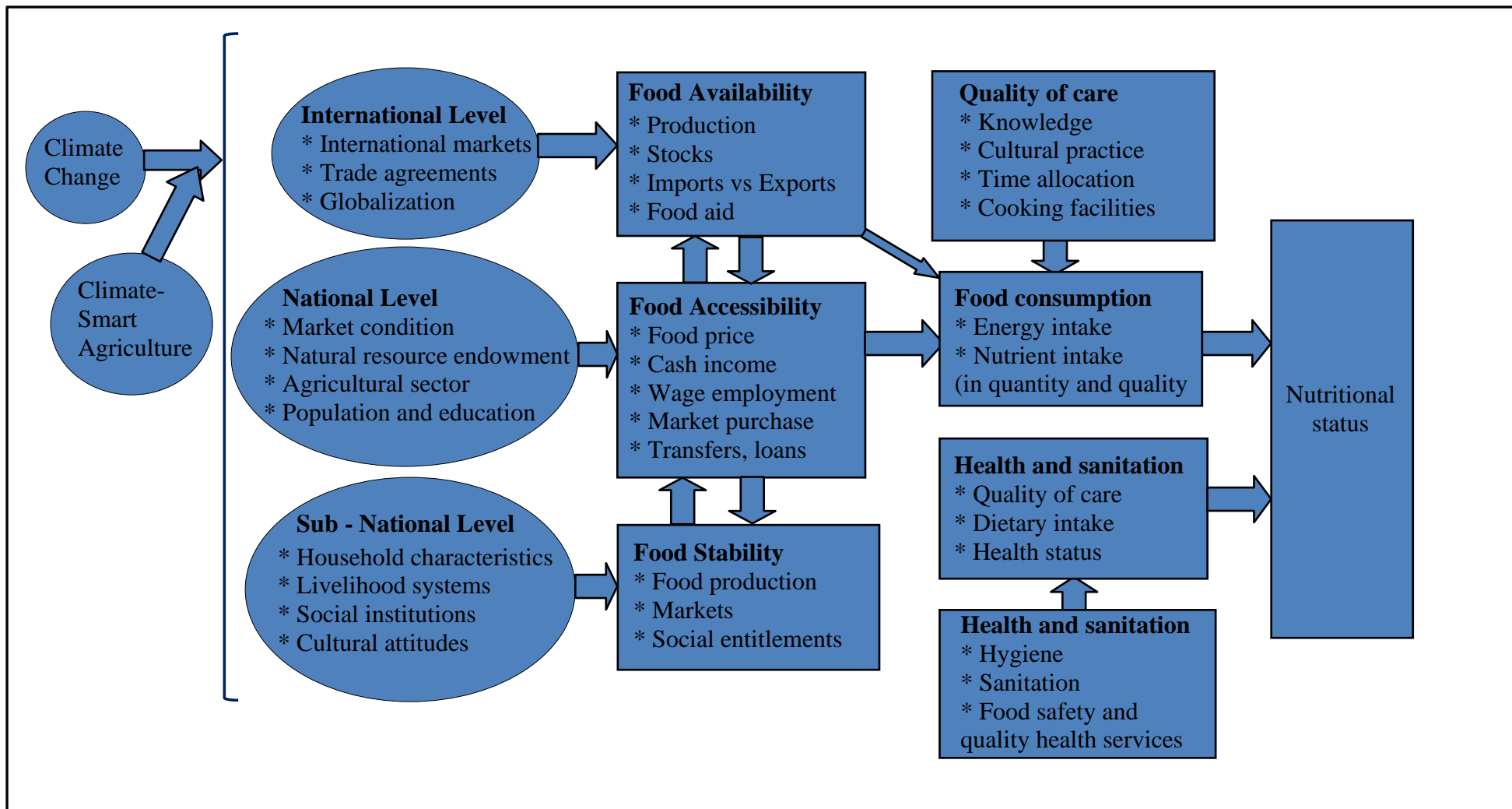


Figure 2. 2: Framework of Food Security  
 Source: Adapted from D’Haese et al. (2011)

Rabe-Hesketh and Everitt (2004) adapted a model to analyze the determinants of food security (equation 4):

$$\phi t = E \left( \gamma_i = \frac{1}{\chi_i} \right) = \frac{1}{1 + e^{-(\beta_i + \sum \beta_j \chi_i)}} \quad (4)$$

$\phi t$  represents the household ( $i$ ) probability to be food secure,  $\gamma_i$  is the observed food security status of the household  $i$ ,  $\chi_i$  denotes the factors that determine whether household  $i$  will be food secure or not, while  $\beta_j$  designates the estimates of the parameters. Representing  $\beta + \sum_i^k \beta_j \chi_i$  as  $Z$ .

Equation 4 can be expressed to determine the probability of food security of household  $i$  as (equation 5):

$$\phi t = E \left( \gamma_i = \frac{1}{\chi_i} \right) = \frac{1}{1 + e^{-Z_i}} \quad (5)$$

From equation (5), the food insecurity probability of a household can be written as  $(1 - \phi_t)$ , which gives another equation that can be expressed as (equation 6):

$$(1 - \phi t) = \frac{1}{1 + e^{Z_i}} \quad (6)$$

On the background of equation (6), the odds ratio, which is  $\phi_t / (1 - \phi_t)$ , can, therefore, be expressed as (equation 7):

$$\frac{\phi t}{(1 - \phi t)} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \quad (7)$$

Equation (7), when the natural logarithm is found, can be further expressed as (equation 8):

$$\text{Ln} \frac{\phi t}{(1 - \phi t)} = \beta + \sum_{j=1}^{k=n} \beta_{ij} + \varepsilon_i \quad (8)$$

Based on the successful calculation of the conditional probabilities of each sampled household, the “partial” effect of each continuous variable on household food security is therefore expressed as (equation 9):

$$\frac{\delta \phi t}{\delta \chi_{ij}} = \phi t (1 - \phi t) \beta_j \quad (9)$$

The “partial” effect of each discrete variable is the difference between the probability estimate of the variable at 1 and 0 ( $\chi_i = 0, \chi_i = 1$ ). This study conceptualizes the food security situation in terms of household dietary diversity and household food consumption.

## **2.3 Empirical Review**

The review covers, among others, explanations of the peculiarity of the small-scale agricultural system in sub-Saharan Africa and the effect of climate change on South African agriculture. It highlights links between climate change, agricultural productivity and food security as well as farmers' perceptions of climate change, their adoption and adaptation behaviors and an overview of the central objectives of CSA. Through this, the section foregrounds the need for an assessment of the potentials and applicability of CSA in small-scale farming system in an African context.

### **2.3.1 The Concept of Climate Change**

The term climate change has become the most popular environmental term and most often than not, is used to connote the shift in modern climate caused by human actions (Abraham, 2018). It is one of the most pressing issues that the world is faced with despite not being new (Abraham, 2018). From the time of its emergence in the public agenda in the mid to late 1980s, climate change has been a subject of exclusive discourse within the science community (Adenle *et al.*, 2015). Since then there have been substantial efforts to push the awareness that the effects of human actions on the climate is threatening both physical and socio-economic systems (IPCC, 2014; Serdeczny *et al.*, 2017).

Sceptics, however, have come up with some evidence to disprove the claim that climate change is predominantly associated with or resulting from the influence of human activities (Adenle *et al.*, 2015). Due to increasing public involvement on the matter, the consequence of climate change has been debated from different views (Vlassopoulos, 2012; Field, 2014). While there are views on the agents and degree of climate change as well as ways of addressing climate change threats, there seems to be a consensus on the fact that the climate is changing (Ampaire *et al.*, 2017).

The United Nations Framework Convention on Climate Change (UNFCCC) describes climate change to be changes in climatic conditions that are caused by human activities, either through direct or indirect means. These bring about an alteration in the global or regional atmospheric makeup in addition to natural variations in climatic conditions that are experienced over some time (Otitoju, 2013; Vermeulen, 2014). The term climate change was adopted by UNFCCC to depict only the changes that could be attributed to human activities. However, climate change

in recent times is seen as changes in current climatic conditions, which, according to the IPCC (2014), is highly likely to be linked to human activities.

The impression that human actions could bring about changes in climatic conditions dates as far back as almost the past two centuries (Weart, 2018). However, it required concerted research efforts to attain the present level of global confidence that human activity is changing the climate (Stocker *et al.*, 2014; Wuebbles *et al.*, 2017). This assurance emanates from the bulk of evidence from the earth's surface, layers of the atmosphere and oceans as well as the geological transformation of historical climates. It is now easy to reject the idea that human activities do not affect the environment (Wuebbles *et al.*, 2017). According to the Australian Department of Climate Change and Energy Efficiency (2012), changes in climatic conditions are to a great extent a result of the increase in greenhouse gases (GHG) caused by human actions. Greenhouse gases trap the heat from the sun in the atmosphere and also bring about a reduction in the amount of heat escaping into space. The untrapped heat which can escape into space is responsible for the changes in the climate system. Different stakeholders in environmental issues therefore view climate change as a significant change in the modern climate escalated by human activities such as deforestation and the burning of fossil fuels.

Despite constant changes in global climatic conditions, the rate at which the climate will change in the future is expected to be more rapid than in the past (Berrang-Ford *et al.*, 2015). There is now general scientific consensus that the continuous accumulation of GHG in the atmosphere contributes to changes in climatic conditions (Adenle *et al.*, 2015). According to Rahman (2013) and Serdeczny *et al.* (2017), the energy emitted back into space by the sun balances that which is being radiated from the sun to the earth. Greenhouse gases built up in the atmosphere trap a quantity of the energy emitted by the earth back to space and thus control the earth's climate by acting as a thermostat in the atmosphere. If not for the role of GHGs, the average earth temperature would have been -18°C.

The primary GHGs are methane, carbon dioxide, nitrous oxide and water vapor. Industrialization and modern ways of life have resulted in a rise in the level of these gases. According to IPCC (2007), the yearly rate of increase of these gases is 0.3, 0.5 and 0.6 per cent for nitrous oxide, carbon dioxide and methane respectively. The IPCC concludes that scientific evidence points to the considerable influence of human activities on the climate. Otitoju (2013) states that the levels of GHGs are increased either by the introduction of new sources or removal of sinks. Sources in this context mean activities that release GHGs, while sinks mean

those that remove the gases (Berrang-Ford *et al.*, 2015). The balance between these two determines the level of GHGs in the atmosphere. Table 2.1 gives a summary of changes to some climatic features and the emanating implications.

Table 2. 1: Aspects of Climate Change and Perceived Implications

<b>Climatic Feature</b>		<b>Implications of Change</b>
Global warming	GHG Concentration	Increase in GHG concentration in the atmosphere as a result of emission of gases through activities such as industrialization.
	Change in world temperature	GHG concentration, coupled with some other factors result in global warming. Global warming causes changes in different characteristics of the human environment.
Depletion of the Ozone layer		There is a steady drop of about 4 per cent in the volume of Ozone in the stratosphere, which has different health implication, part of which is cancerous diseases, escalating extreme weather conditions through an opening of the curtain that protects the earth from direct rays of the sun.
Shrinking ice sheets		Loss of ice sheets adds to the problem of rising in sea level.
The rise in Sea Level		A continuous increase in sea level tends to result in overflow in many island states, low-lying delta regions, displacing many occupants of such areas.
Ocean Acidification		There has been a continuous increase in the Carbon (IV) Oxide contents of oceans, thereby increasing the ocean acidity by 30 per cent.
Warming Oceans		The increase in heat absorbed by the earth has resulted in ocean warming, which is capable of causing a huge change or destruction of ocean habitations.

Source: Adapted from Rahman (2013)

There is now a shift in the discourse of climate change from being merely an issue of environmental degradation to a development issue (Rahman, 2013; Abraham, 2018). As a result of the change in definitions and perspectives, there is an increased level of involvement

of public authorities in the management of the challenge of climate change (Rahman, 2013). For instance, authorities from the science community would be interested in the factors causing climate change and revealing the consequences as environmental degradation while a development organization would view climate change and the emanating degradation as the root of underdevelopment causing food insecurity and poverty (Abraham, 2018).

Thus far, the primary approach of addressing climate change has been mitigation, with the consideration that adaptation is less critical. However, some scholars are of the view that mitigation and adaptation are complementary approaches (Vlassopoulos, 2012; Adenle *et al.*, 2015). Greenhouse gas mitigation brings about a reduction in the rate at which the climate changes, thereby creating more room and time for the needed response from the society. Through this, there can be a reduction in the cost of adaptation (Adenle *et al.*, 2015).

The World Bank (2008) reported that climate variability influences crop production through five significant ways; changes in temperature, precipitation, carbon dioxide (CO<sub>2</sub>) fertilization, surface water runoff and variation in climatic conditions. Climate change threatens livestock production as well because of its negative influence on water availability, quality of forage, livestock diseases, milk production and reproduction physiology (Rojas-Downing *et al.*, 2017). Despite the increasing threat climate variability poses to socio-economic development, the agricultural sector is more susceptible to climate change than other sectors, and that is because of the level of the dependence of agricultural activities on the condition of the climate (Descheemaeker *et al.*, 2016).

The issue of climate change, either due to human activity or natural variability expressed as extreme temperature, drought, flooding and increased level of salinity of water supply that could be used for irrigation (IPCC, 2014), is a global subject of concern and debate. It needs solutions with international coordination and cooperation to help countries achieve low-carbon economies. Activities such as prevailing slash and burn agriculture, and erosion in conjunction with poverty have complicated the problem of global warming and changes in climatic conditions in developing nations (Lamboll *et al.*, 2017).

### **2.3.2 Climate Change Pattern in Sub-Saharan Africa**

Based on IPCC's prediction, Africa will be highly affected by increase in variability associated with temperature and precipitation (IPCC, 2014). Africa experienced increased warming of about 0.5°C in the 20th century and the mean temperature per year is predicted to continue to

increase by 3 – 4°C by 2080, which is higher than the global average (Branca *et al.*, 2012; Serdeczny *et al.*, 2017). Changes in temperature and precipitation patterns will increase shortage of water, shorten cultivation periods in some areas, increase the rate of occurrence and extent of drought and flood, change the patterns of pests and diseases of plants and animals and render some areas less suitable for agricultural activities, thereby putting strain on natural and agricultural systems (IPCC, 2014). Areas in Sub-Saharan Africa known to be highly vulnerable to weather instability are predicted to be affected the most with the decline in agricultural productivity by 15 – 35 per cent (IPCC, 2014).

As an international effort to rise to the challenge of climate change, the Paris agreement adopted at the Conference of the Parties 21 in 2015 and ratified in 2016 recognized the need for prompt and practical responses to the urgent threat of climate change. The agreement considers the specific needs of third world nations which are susceptible to the impact of climate change and proposes measures in response. Implementing the Paris Agreement by countries will help provide a roadmap for actions that are climate smart, targeted towards emission reduction and climate resilience. The ultimate aim is to achieve sustainable development goals, in which alleviating poverty and ensuring food security and agricultural sustainability are essential (United Nations, 2017).

Africa is recognized as a highly vulnerable continent in terms of food insecurity due to its dependence on natural resources and agriculture (Dooley & Chapman, 2014). This situation has made the issue of climate change adaptation critical for policymakers and stakeholders in many African countries (Kitsao, 2016). Sub-Saharan Africa is identified to be highly vulnerable to climate change (IPCC, 2014; Niang *et al.*, 2014). The region, whose population is projected to reach 2 billion by the middle of the century and 4 billion by its end, is undergoing rapid development and is quite diverse in terms of ecology and climate (UNDESA, 2013; Niang *et al.*, 2014).

### **2.3.2.1 Change in Temperature**

According to Serdeczny *et al.* (2017), the level of warming predicted for Sub-Saharan Africa is just a little less reliable compared to that predicted for the global land area. In a situation where there is low emission, the summer temperature is expected to rise by 1.5°C above the 1951 – 1980 baseline until 2050 (Serdeczny *et al.*, 2017). However, in a high-level emission situation, warming is expected to continue to the close of the century by about 5°C above the 1951 – 1980 baseline. Geographically, this warming is uniform in its distribution although

inland regions experience it more. In Southern Africa, there is a huge difference in the warming that takes place between the region with low emissions and that with high emission. This may be attributed to positive feedback regarding precipitation. There is a high tendency of a substantial decrease in precipitation with high emissions, thereby restricting the effectiveness of the cooling mechanism of the soil (Serdeczny *et al.*, 2017).

#### **2.3.2.2 Heat Extremes**

Heat extremes, which are temperatures higher than the historical norm by 3 and 5 standard deviations, are expected to increase under the two levels of emission, however, with a massive difference in the rise experienced under the two situations (Schellnhuber *et al.*, 2014). By the end of the century, about 75 per cent of the summer months is expected to be hotter than 5°C of land surface warming (3.7°C of global warming), a heat extreme significantly above the projected global average (Coumou & Robinson, 2013). Serdeczny *et al.* (2017) reveal that between 2071 and 2099, almost all the summer months in sub-Saharan Africa would be characterized by heat extremes higher than 3°C of land surface warming (2.2°C of global warming), while 60 per cent of these summer months will experience heat extremes higher than 5°C of land surface warming. During this period, there is going to be a shift in the pattern of climate in Africa.

#### **2.3.2.3 Change in Precipitation**

Sillmann *et al.* (2013) predict changes of between +5 and –15 per cent wet-day precipitation for West African countries with very wet days experiencing a stronger increase of about 50 to 100 per cent increase in East African countries. Total wet-day precipitation in the southern part of Africa was predicted to fall by 15 to 45 per cent and very wet day precipitation to rise by about 20 to 30 per cent. Part of the west coast of Southern Africa is projected to experience about 30 per cent decline in very wet days. Sillmann *et al.* (2013) found a coincidence of increases in consecutive dry days with a decrease in very wet precipitation days and maximum successive five-days precipitation showing the intensification of dry conditions. The changes in wet-day precipitation would be far less prominent in a low-emission situation.

#### **2.3.2.4 Aridity and Evapotranspiration**

The aridity index is used to identify areas that are deficient in structural precipitation. It is described as the total precipitation in a year divided by potential evapotranspiration (Serdeczny

*et al.*, 2017). The average monthly potential evapotranspiration per year rises with global warming and this is because it is mainly temperature-dependent. From an analysis carried out by Serdeczny *et al.* (2017), this increase is observed across Sub-Saharan Africa, but there is slight decrease in potential evapotranspiration in East Africa and the Sahel region. The changes in aridity are predicted to show the most substantial deterioration in Southern Africa. On one hand, more aridity is experienced in Southwestern Africa as a result of a decrease in rainfall that is aggravated by an increase in evapotranspiration and influenced by temperature. On the other hand, there is a higher aridity index recorded for East Africa and this correlates with increased levels of rainfall predicted by global climate models.

### **2.3.2.5 Rise in Sea Levels**

Studies predicting the nature of the future rise in sea levels project a non-uniform rise across the globe. The rise predicted for the coastlines in Sub-Sahara Africa is about 10 per cent higher than the global average (Serdeczny *et al.*, 2017). A study by Serdeczny *et al.* (2017), comparing West African and southeast African locations shows no significant difference in projections. There is a projection of a rise in sea level by 0.4 to 1.15m in a 4°C situation and a lower increase of 0.2 to 0.7m in a 2°C situation.

### **2.3.3 Overview of Climate Change Trend in Sub-Saharan Africa**

The historical trend of climatic conditions in sub-Saharan Africa reveals a warming temperature of about 0.7°C with a decline in rainfall over a large area of the semi-arid region and increased levels of rainfall in the eastern and central parts (Juana *et al.*, 2013). There are expectations that these trends will continue and will be accompanied by a rise in sea levels and increased occurrences of droughts and floods throughout the 21st century (Sani & Chalchisa, 2016). The same study established an increasing trend for temperature, a 2 and 7 per cent increase in precipitation pattern in West Africa and East Africa respectively with a 4 per cent decline in the Southern Africa.

Different studies have projected a general decline in precipitation and water availability. Between 1970 and 1995, water availability has decreased almost three times. The average release of rivers in West Africa has reduced by 40 to 60 per cent (Sani & Chalchisa, 2016). According to Arnell (2004), about 370 million people in Africa will experience worse water stress by the quarter of the 21st century. A study by Sani *et al.* (2016) reveals that the mean

annual temperature in the western region of Ethiopia increases by 0.096°C every year while yearly rainfall in the same region declines by about 46.75mm per year.

### **2.3.4 Climate Trends across South Africa**

South Africa is characterized by a plateau topography, Agulhas and Benguela ocean currents and a sub-tropical latitude, which are highly responsible for the semi-arid nature of its climate. There is a seasonal alternation of low-level zonal circulation, while rainfall circulates as a result of influences from the South Atlantic and Indian Ocean sea surface temperatures coupled with the Pacific El Nino southern oscillation. As a result of local overturning circulations and surface fluxes coupled with forcing experienced externally, the available moisture is subjected to internal recycling (Kruger & Nxumalo, 2017).

Studies have shown a temperature trend of  $\sim +0.02^{\circ}\text{C}\cdot\text{yr}^{-1}$  conforming with the global average but a weak and heterogeneous trend for rainfall (Jury, 2013; Kruger & Nxumalo, 2017). According to Jury (2018), the surface air temperature rises by about  $0.03^{\circ}\text{C}\cdot\text{yr}^{-1}$  and there is more warming in the northern and western parts of the country. Rainfall trends are quite small. The yearly variation associated with the Pacific El Nino Southern Oscillations overshadows the rainfall trend (Dieppois *et al.*, 2015).

There has been notable warming by about  $0.02^{\circ}\text{C}\cdot\text{yr}^{-1}$  in South Africa between 1980 and 2014 (Jury, 2018). The author projects that temperatures would increase in the future by  $\sim 1^{\circ}\text{C}$ , whatever the season. Rainfall is expected to increase in the eastern part of South Africa and decrease in the western part (IPCC, 2013; Jury, 2018). Fluctuations observed in rainfall surpass that of temperature. During this period (1980 – 2014), the eastern lowlands experienced a fall in heat while rainfall and vegetation showed no significant changes. However, future projections, which is as a result of increasing GHGs, reveal drying in the western plateau. Atmospheric reanalysis confirmed a  $\sim 0.01^{\circ}\text{C}\cdot\text{yr}^{-1}$  trend in the southern part of the country.

### **2.3.5 Perception of Farmers on Climate Change**

Climate change awareness has been established as a crucial pre-condition for climate change adaptation and mitigation (Juana *et al.*, 2013). Farmers in developing countries, considering their vulnerability, are the right targets to be educated about climate change and its effects. Gandure *et al.* (2013) and Makate *et al.* (2017) report on how South African farmers perceive increased temperatures and the decline in rainfall or precipitation. Warmer temperatures in

South Africa correlate with high evaporation and increase in crop water requirements (Makate *et al.*, 2017). Livestock farmers in South Africa noted a rise in temperature with a dominance of drought in the weather condition of the area (Tibesigwa *et al.*, 2017).

Studies on five African countries – Benin, Togo, Niger, Ghana, and Burkina Faso – report on farmers' views on changes in rainfall patterns with delays in rain and early cessation as well as the significant rise in temperatures resulting in more hot days (Akponikpè *et al.*, 2010; Callo-Concha, 2018). From their study of Senegalese farmers in the country's savannah region, Mertz *et al.* (2009) and Khouma *et al.* (2014) point out that the farmers are quite aware of winds and excess rainfall as highly destructive aspects of climate change. The study further points out that farming households in the area observed a drop in rainfall and a rise in temperatures across the year with the shortening of cold periods and lengthening of hot periods.

Terdo and Adekola (2014) and Ayanlade *et al.* (2018) report on increased temperatures in southwestern Nigeria. According to their report, farmers noted higher rates of evapotranspiration, attested to the experience of violent rain and complained about a delay in rainfall and early cessation. Most farmers in South Africa, Zimbabwe and Zambia also reported long-term rises in temperature coupled with changes in the timing of rainfall and the frequency of droughts (Makate *et al.*, 2017).

Studies have revealed that factors that could influence how farmers perceive climate change in South Africa include access to extension services. The likelihood of perceiving changes in climatic conditions is associated with the information they receive (Gandure *et al.*, 2013). The implication is that the awareness and perception of climate change determines responses from farmers. Furthermore, farmers with a higher farming experience are more likely to notice changes in the conditions of the climate, while the wealth of farming households positively correlate with an increased likelihood of the climate change awareness of the households (Below *et al.*, 2015; Ayanlade *et al.*, 2018).

### **2.3.6 Impacts of Climate Change on Agriculture**

There seems to be growing concern about climate change because of the threats it poses to agriculture. Unfortunately, the agricultural sectors of sub-Saharan African countries show more vulnerability to the changing climate when compared with other countries (Serdeczny *et al.*, 2017). The region has already been battling with harsh climatic conditions, mostly warm baseline temperatures and low precipitation (IPCC, 2014; Tibesigwa *et al.*, 2015). All these are

exacerbated by limited irrigation opportunities and low levels of adoption of improved technologies caused by economic constraints (FAO, 2014).

Climate change influences agricultural production mainly through the changes it causes to precipitation patterns, temperatures, fertilization of carbon dioxide, variation in climatic conditions and the runoff of surface water (Arakelyan *et al.*, 2017). Crop production is directly affected by changes in temperature and precipitation. Precipitation, being the primary source of freshwater, is the determinant of soil moisture level and therefore an essential influencer of crop growth (Calzadilla *et al.*, 2014). De Trincheria *et al.* (2015) established that higher levels of precipitation result in the reduced variability in crop yield. Therefore, a high level of rainfall shrinks the gap between yields from rain-fed farming and irrigation farming. However, excessive increases in precipitation levels brings about adverse conditions like flooding and waterlogging, which are highly damaging to agricultural production (Calzadilla *et al.*, 2014).

Temperature and soil moisture influence the growing season, development of crops and water requirements. Increase in temperature shrink frost periods, thereby enhancing cropping activities in cool-climate croplands. In contrast, an increase in temperature in arid and semi-arid regions brings about a shortening of crop cycle and reduction in yields of crops (Arakelyan *et al.*, 2017). Increases in the atmospheric concentrations of carbon dioxide enhance plant growth and improve water use efficiency thereby affecting water availability (Calzadilla *et al.*, 2014). Calzadilla *et al.* (2014) also notes that varying climatic conditions, especially fluctuations in rainfall patterns, are crucial to rainfed farming systems. Limited soil moisture leads to a decline in crop productivity and raises the risks associated with production in rainfed agriculture. Despite the role of irrigation in reducing the risks of climate variability, irrigation-fed agriculture still depends on surface runoff or the availability of groundwater, which are always influenced by climate change.

There have been several studies on how climate change influences the agricultural system in Africa in the last decade. Juana *et al.* (2013) project high vulnerability to global warming for African countries, considering their experience of high temperature already. According to the FAO (2014), the vulnerability of agricultural systems in African countries can be attributed to the degradation of the environment and varying rainfall patterns, while climate change exacerbates poverty and food insecurity. Calzadilla *et al.* (2014) project output decline for most crops in Africa, except where there is technological intervention, stating that apart from adaptation, heat increases will significantly reduce crop yields.

Climate change highly threatens food security due to the substantial adverse impact it has on dryland cropping or rain-fed farming, which is the basis of small-scale farming systems in Africa (Turpie & Visser, 2013; Tshuma, 2014). While small-scale farmers have suffered the impact of climate change, large-scale farmers in some areas in Africa may enjoy some benefits due to the fact that increase in temperatures could bring about increase in crop yields cultivated through irrigation (Turpie & Visser, 2013). In their study of the effect of climate change on the net revenues and food adequacy of farming households in South Africa, Tibesigwa *et al.* (2015) note that warmer and drier climates had adverse effects on net farm revenues, resulting in serious food security problems. They also project a decline in agricultural productivity as a result of climate change, further stating that food price increase will result in the reduction of food availability and worsen malnourishment in children.

Some studies on the effect of climate change on revenues from crop farming have shown net revenues having a negative and positive relationship with temperature and precipitation respectively, with elasticities of -1.3 and 0.4 in that order. An increase in temperature by 2.5°C and 5°C was estimated to result in losses in farming in Africa by \$23 billion and \$38 billion respectively, while a decrease in precipitation of 7 and 14 per cent was estimated to bring about \$4 and \$9 billion losses in net revenues. The cumulative effect of climate variability would show significant variance across countries. However, more impacts are expected in countries already experiencing hotness and dryness (Turpie & Visser, 2013; Serdeczny *et al.*, 2017).

Studies on the effect of climate change on livestock production also show the likelihood of a negative impact on net revenues. However, Thornton and Herrero (2014) and Shikuku *et al.* (2017) reveal that small farms, with opportunities of substitute animals that are heat tolerant, could experience lesser adverse effects than larger farms with less flexibility and complete reliance on cattle farming. Wetter conditions have been noted to be more detrimental to grazing animals if there is a shift in vegetation from grasslands to forests and there could also be an increase in the incidence of diseases for livestock.

### **2.3.7 Climate Change Impact on South African Agriculture**

It is generally accepted that the world will continue to experience changes in climatic conditions (Abraham, 2018). South Africa, like other Sub-Saharan African countries, have been reported to be highly vulnerable to climate change, considering its dependence on agricultural activities (Ncube *et al.*, 2016). South Africa is said to be dry with annual precipitation lower than the world's average (Department of Environmental Affairs, DEA,

2011). The country experiences an uneven distribution of rainfall and has a warm baseline climate. It is getting hotter and coupled with scarce water resources, the country's condition is increasingly becoming unfavorable for agricultural growth (Ncube *et al.*, 2016). The DEA (2011) estimates about 2 to 13 per cent water shortage for South Africa, a situation which will worsen the already adverse effects of climate change.

Agricultural activities in South Africa claim about 65 per cent of the surface water, while about 67 per cent of available land is not suitable for productive cultivation of crops (DEA, 2011). Despite 1.3 million ha of the total cultivated land area being under irrigation, South Africa has minimal irrigation potential (DEA, 2011) which increases its vulnerability to climatic shocks and reduces adaptation capacity. Furthermore, low technology adoption as a result of human and finance resource constraints adds to the susceptibility of the country's farming systems to climatic shocks.

Studies on the Sub-Saharan region reveal losses to crop farming and livestock production as a result of climate change (Ncube *et al.*, 2016; Zougmore *et al.*, 2018). Tibesigwa *et al.* (2017) notes that climate change would influence the agricultural productivity of crop and mixed farms in South Africa. According to Zougmore *et al.* (2018), climate variability poses a significant risk to the African agricultural sector and in the case of South Africa, climate variability is a particular food security (Tibesigwa & Visser, 2015).

Different studies have reported on the impacts that climate change has on crop and livestock production in South Africa. Deressa *et al.* (2005) notes that climate change adversely affects sugar cane production. Benhin (2008) found that there is more climate shock vulnerability with dry-land farming than with irrigated farming and a study by Blignaut *et al.* (2009) reveals that yields from field crops would drop with a reduction in precipitation especially for rain-fed crops. Tibesigwa *et al.* (2015) found out that crop farming is most vulnerable to climate change while mixed farming is least vulnerable. Small-scale farmers in South Africa are reported to be more susceptible to climate change when compared with their large-scale counterparts (Tibesigwa *et al.*, 2016). Tibesigwa *et al.* (2017) also notes that season and location are crucial determinants of the potential impacts of climate variability on the cultivation of crops and that increases in temperature and precipitation have a negative and positive effect on net revenue respectively. Mutoko *et al.* (2008) studied about 416 crop farms, 53 per cent of which are large-scale and 47 per cent small-scale farms. Table 2.2 summarizes the impacts of selected climate models on net revenues.

Table 2. 2: Impacts of selected Climate Models on Net Revenues (US \$/ha)

Year	CGM2		HadCM3		PCM	
	2015	2100	2015	2100	2015	2100
Change in temperature (°C)	34	9	3.9	9.6	23	5.5
Change in precipitation (%)	-4	-8	-8	-15	-2	-4
Impact	Actual (%)	Actual (%)	Actual (%)	Actual (%)	Actual (%)	Actual (%)
Full sample	-12.88 (-4.22)	-40.79 (-26.65)	-16.26 (-5.32)	-93.24 (-30.52)	-5.14 (-1.68)	-29.99 (-9.82)
Irrigated	-15.91 (-3.4)	-113.99 (-24.43)	-20.23 (-4.34)	-134.55 (-28.84)	-5.34 (-1.15)	-41.16 (-8.82)
Dryland	-43.2 (-27)	-55.24 (-34.74)	-44.1 (-27.74)	-59.06 (-37.44)	-41.63 (-26.18)	-46.29 (-29.12)
Large scale	-43.11 (12.01)	-220.16 (-61.41)	-49.39 (-13.78)	-248.21 (-69.23)	-20.65 (-5.76)	-92.99 (-25.94)
Small scale	-47.29 (18.61)	-204.6 (-80.49)	-52.73 (-20.74)	-227.2 (-89.39)	-25.05 (-9.86)	-93.86 (-36.93)

() The numbers in parentheses denote the percentage change in revenue as a result of the considered change in climate scenarios.

Source: Mutoko et al. (2008)

Table 2.2 reveals that climate change could have a more severe impact than what was predicted by earlier studies. The focus was on crop farming, livestock and mixed farming. The results show that dryland cropping is more vulnerable to climate change than irrigated cropping. It also shows higher losses in net revenue (US \$) for small-scale farmers; a loss of -36 to -89 per cent projected for 2100.

Seo et al. (2009) reveal different impacts for South Africa under different conditions and models using the Canadian Climatic Centre (CCC) and Parallel Climatic Model (PCM). They found out that while the prediction for CCC has a higher impact than PCM, the result in South Africa generally is not as severe as in many other African countries. Table 2.3 shows the

predictions from different scenarios and reveal that the CCC scenarios are more significant than that of the PCM.

Table 2. 3: Change in revenue from crop and livestock production (US \$/farm)

	Impact small (\$/farm)	per % of livestock farm income	Impact per large farm (\$/farm)	% of livestock income
<b>2020</b>				
Change_CCC	151	24%	-290	-9%
Change_CCSR	259	42%	-317	-10%
Change_PCM	-26	-4%	-545	-17%
<b>2060</b>				
Change_CCC	332	53%	-639	-20%
Change_CCSR	180	29%	-750	-24%
Change_PCM	40	6%	-709	-23%
<b>2100</b>				
Change_CCC	720	116%	-722	-23%
Change_CCSR	945	152%	2	0%
Change_PCM	194	31%	-842	-27%

Note: Small-scale farms have a baseline income of \$623 per farm while large scale farms have \$3142 per farm

Source: Seo et al. (2009)

### 2.3.8 The Concept of Adaptation

Climate change adaptation involves responding to a perceived vulnerability, expectations of, and actual climatic stimuli with the impacts, by adjusting to human, physical, ecological and socio-economic systems (Otitoju, 2013). Climate change adaptation in agriculture involves the adjustment of agricultural activities, primarily management actions that take place in response to climate change (Arslan *et al.*, 2015; Arakelyan *et al.*, 2017). Adaptation processes could take three different forms which could be anticipatory and reactive; they could be private and public, and could also be autonomous and planned (Otitoju, 2013).

Adaptation is a crucial aspect of the assessment of climate vulnerability and climate change impact. Adaptation responses can be classified based on the ownership of adaptation measures or strategies. Autonomous responses are those that take place without intervention from the government or a public agency (Arslan *et al.*, 2015). Independent adaptations are reactions to

climate stimuli, set off by market or welfare changes that are themselves caused by actual or anticipated changes in climatic conditions. By contrast, planned adaptation is policy-driven and emanates from outcomes of deliberations or policy decisions by public agencies. The discussions and decisions hinge on the consciousness that climatic conditions will change or have taken a new turn and that steps are needed in response (Otitoju, 2013; Arslan *et al.*, 2015).

Autonomous adaptation response corresponds to private adaptation, which is assessed by individual farmers in terms of costs and benefits. Planned adaptation, on the other hand, corresponds to public adaptation by being policy-oriented. With regard to autonomous adaptation, the expectation is that there will be efficient adaptation on the part of the farmers and that markets are sufficient encouragement for adaptation efficiency in traded agricultural goods (Arakelyan *et al.*, 2017). However, with the problem of market imperfection such as inadequate information on climate change or land tenure insecurity, there is a high tendency for ineffective risk management by farmers. Therefore, there is a need for synergy between public and private efforts so that the burden on farmers may be lightened and for desired results to be achieved.

There are several characteristics by which adaptations can be identified and distinguished. Examples include intent and purposefulness, timing and duration, scale and responsibility, and form (Abraham, 2018). Intent and purposefulness relate to the difference between conscious adaptation responses and spontaneous adaptation responses carried out as a result of on-going management action. These are planned strategies within the socio-economic systems, whereas adaptation by the private sector and individuals can be autonomous, planned or both. For instance, if a farmer decides to gradually phase out a crop variety for another that seems to perform better in a given climatic condition, such a decision could be labelled spontaneous and autonomous. However, the choice is a conscious one.

Timing of adaptation distinguishes between adaptation actions that are anticipatory, concurrent and responsive. However, although the differences may be clear cut in theory, it is not very distinct in practice (Adenle *et al.*, 2015). For example, based on the experience of drought in recent years, a farmer who may be apprehensive of something similar or worse in the future may adjust some production activities or financial arrangements in response. The timing distinction is not really of use in the cited instance, as the response is both reactive and proactive. By contrast, duration of adaptation shows differences in adaptation responses based on time frames. It could be tactical – which is short-term – or strategic, which is a long-term

response (Rosegrant *et al.*, 2008; Ahmed, 2016). In tactical adaptations, responses are made to deal with the climatic conditions in the short-term while strategic adaptations involve structural changes to farming activities or management over the long term. Examples of tactical adjustments are sales of livestock, feed purchase, and ploughing a crop while strategic adaptation includes the use of insurance and changes in land use.

### **2.3.9 Climate Change Adaptation Strategies**

Despite the challenges faced with climate change in the agricultural sector in Sub-Saharan Africa, reducing the adverse impact of climate change through adaptation practices is still a possibility (Ojo & Baiyegunhi, 2020). Adaptation strategies refer to adjustments in natural or human systems in response to actual or expected changes in climatic conditions (Nhamo *et al.*, 2019). Embracing climate change adaptation strategies has an estimable importance in enhancing food security in Sub-Saharan Africa, if properly planned in terms of an extensive policy among small-scale farmers (Tubiello *et al.*, 2015).

With the stress from climate change, it is important to pay attention to building resilience, enhancing adaptive capacity and building resilient food systems that can mitigate against climate change impacts through innovative technologies and practices (Tubiello *et al.*, 2015). The knowledge of available adaptation strategies and their potentials is associated with the knowledge of climatic trends and projections (Nhamo *et al.*, 2019).

Previous studies have revealed that changes in climatic conditions will affect the current and future agricultural systems due to modifications in the environmental system as a result of shifts in season (Ncube *et al.*, 2016; Zougmore *et al.*, 2018). For instance, climate change and variability, coupled with other factors are negatively affecting the farming system in Southern Africa thereby adversely impacting its capacity to meet the food demand from its growing population (Nhamo *et al.*, 2019). The challenge of the growing demand for food in the region is being complicated by increasing temperatures, changes in the patterns of rainfall and land degradation (Nhamo *et al.*, 2019).

Different studies have been conducted on the adaptation strategies and coping mechanisms farmers adopt in addressing climate variability in Sub-Saharan Africa. Gandure *et al.* (2013) and Ahmed (2016) reveal that most farmers in the region, particularly those in areas with lower precipitation, have shifted from crops that require much water to crops that require moderate amounts of water for cultivation. Crop farmers in areas with frequent flooding have shifted to

short-cycle crops and the time of planting to avoid periods with heavy rainfall (Arslan *et al.*, 2015).

In adapting to climate change, farmers have moved to crop diversification; they change planting days to cope with changes in the pattern of precipitation, plant tree crops, practice mixed cropping and also generate income from alternative sources (Gandure *et al.*, 2013; Sani *et al.*, 2016). Farmers in the southern part of Africa where countries undergo severe water stress have innovated water conservation techniques including water harvesting, wastewater re-use and irrigation (Gandure *et al.*, 2013; Sani *et al.*, 2016). West African farmers cope with short intensive rainy seasons with strategies such as planting short duration crops, soil conservation and upland farming (Zougmore *et al.*, 2016). Livestock farmers dig boreholes in dry regions, diversify their income-generating activities and shift to livestock with a high tolerance for water scarcity and high temperature (Mandleni & Anim, 2011; Zougmore *et al.*, 2016).

### **2.3.10 Overview of Climate-Smart Agriculture**

A lot of attention has been paid to the sustainable development of agriculture in Sub-Saharan Africa. One of these is the promotion of CSA among farmers, especially small-scale farmers (Branca *et al.*, 2011; Akrofi-Atitianti *et al.*, 2018). The emergence of CSA can be traced to a 2010 conference at the Hague where there was a productive discussion on approaches towards mitigating the effects of climate change. Since then, there has been growing advocacy for the adoption of CSA as an efficient way to enhance agricultural productivity, especially in a changing climate. Climate-smart agriculture offers a triple-win benefit to farmers through improved productivity, reduction in GHG emissions and enhanced adaptation to changes in climatic conditions and its impacts (Lipper *et al.*, 2014; Mango *et al.*, 2018).

Lipper *et al.* (2014) posit that CSA can transform and reorient agricultural systems to enhance food security under threat from climate change. They note further that it brings about increased levels of adaptive capacity through efficient resource utilization and the establishment of agricultural systems that can withstand the threats of climate change. The crux of CSA is adequate and proper land use, soil and water conservation and efficient residual management which are fundamental to productivity and are also affected by climate variability (Branca *et al.*, 2011; Kitsao, 2016). According to the FAO (2010), CSA includes agricultural adaptation methods that bring about sustainable increase in productivity, reduction or removal of GHGs and the enhancement of the achievement of food security and agricultural development goals. Climate-smart agriculture aims at maximizing benefits and minimizing undesirable trade-offs

across multiple goals. Further account by FAO (2010) reveal that CSA practices could be incorporated into a single farming system and then open up numerous benefits that can bring improvement to the livelihoods and incomes of farmers, mainly small-scale farmers. For small-scale farmers, CSA can facilitate greater household food security, increase in revenues and stronger resilience (Maguza-Tembo *et al.*, 2017).

The approach of CSA is promoted as the ‘holy grail’ of development in the agricultural sector given that agriculture is key to climate change adaptation and mitigation (Naess, 2011; Makate *et al.*, 2018). The three main pillars of CSA are sustainable increase in agricultural productivity and incomes, adaptation and resilience to changes in climatic conditions and reduction or removal of GHGs. These are fundamental to any agricultural technique or practice that would be considered climate-smart (Beddington *et al.*, 2012; Mathews *et al.*, 2018). The concept of CSA is, as a result, an excellent approach of integrating the climate change mitigation and agricultural sustainability (Makate *et al.*, 2018). It is designed to provide a guide for the transformation and reorientation of agricultural systems to bring about effective and sustainable food security by enabling climate friendly farming techniques.

Dooley and Chapman (2014) argue that techniques that can simultaneously yield adaptation, mitigation and food security benefits to agricultural activities is better than any other strategy that could be employed in production. In this regard, CSA has the potential to facilitate the following:

- **Increase global food production:** CSA has the potential of improving productivity and providing adaptation to climate change so that crops develop more resilience to the adverse effects that come from the change and meet up with the increasing demand for food.
- **Wise management of land:** CSA also has the potential of weakening the pressure on available land (such as forests) for cultivation.
- **Political sensitivity of the agricultural sector:** Since the enhancement of food security is a pillar of CSA, there would be fewer controversies on its adoption compared to other approaches for reducing emissions from agricultural activities.
- **Global support for sustainable agricultural activities:** CSA can also contribute to global political action towards sustainable agriculture.

According to Pye-Smith (2011) and Wekesa *et al.* (2018), examples of some CSA include:

- Conservation agriculture; which has to do with ploughing methods that reduce the extent of soil disturbance or turn over while allowing crop residue on the field after harvesting, minimize soil erosion;
- Crop rotations and planting of more resilient varieties of crops; which are more productive and can adapt better to climate change, for example having better resistance to drought or flood;
- Agroforestry, intercropping with nitrogen-fixing legumes and cover cropping; which could boost soil fertility and also protect the soil from exposure to wind and water erosion thereby increasing productivity and adaptation to climate change;
- The use of livestock manure to fertilize the soil, as well as increasing the ground biomass; which can help improve the water retention capacity of the soil, bring about more soil carbon sequestration and also the replenishment of the soil nutrient (Bryan *et al.*, 2011). The likely effect of this is the improvement in soil functionality and yields and even more agricultural activities with less need for inorganic fertilizers, which could cause trade-off of elements in the environment;
- Efficient management of manure in livestock production (composting);
- Diet improvement for animals to achieve more protein production with less feeds and lower emissions;
- Efficient pasture management (improved sowing varieties of pasture, rotational grazing); and
- Better health management for livestock with less reliance on antibiotics.

Dooley and Chapman (2014) reaffirm the triple benefits of CSA practices and state that these benefits could contribute immensely to agricultural sustainability and global food security in the following ways:

- Adaptation benefits: Increased frequency and intensity of heavy rainfall, which are projections of climate change, could be checked through more soil cover and roots as a preventive measure against erosion. The use of soil organic matter and soil cover to retain soil moisture could also be an adaptation measure against drought.
- Food security benefits: Intercropping and composting have the potential of improving soil fertility thus increasing yield per farm plot. More food from a unit area of land could be produced through intercropping.

- Mitigation benefits: The adoption of some CSA practices like composting and planting of cover crops could reduce the dependence on inorganic fertilizers thereby reducing GHG emissions from their use.

Climate-Smart Agriculture works to concurrently address climate change problems, alleviate food insecurity and manage the ecosystem in an efficient manner by incorporating social, environmental and economic dimensions of sustainable development (FAO, 2013). This concept attempts to set a global plan for a productive venture in research and development regarding the agricultural sector as it relates to climate change. Climate-Smart Agriculture evaluates economic, environmental and social situations in a way specific to locations to point out and embrace suitable technologies and practices needed for a successful venture in farming activities (FAO, 2013). A vital element in the concept of CSA is an approach to landscapes built on ecosystem management, water and land use sustainability (Williams *et al.*, 2015).

### **2.3.11 Climate-Smart Agriculture in Sub-Saharan Africa**

In recent time, CSA has been promoted as a laudable approach to food security in the small-scale farming system (Ouédraogo *et al.*, 2019). While the concept is still being studied, many agricultural practices that fit into CSA profile have been identified. Different authors have reported successful outcomes of CSA technologies that have been tested (Sanou *et al.*, 2016; Andrieu *et al.*, 2017; Traore *et al.*, 2017). However, there is still a relatively low level of CSA uptake in the small-scale farming system in Africa. In many countries, south of the Sahara, CSA uptake is thought to be hampered by different factors (Mkwambisi *et al.*, 2016). Akrofi-Atitianti *et al.* (2018) identified farm location, age and access to extension services as critical to CSA uptake. Murray *et al.* (2016) noted that there is the need to pay attention to gender analysis for a successful development and uptake of CSA technology.

The adoption of CSA could be of immense help to the farming system in Sub-Saharan Africa, by helping the small-scale farmers maximize the potentials locked up within the small-scale farming system. This section highlights, as examples, the contribution of CSA to the farming system in Kenya, Rwanda, Malawi and Uganda.

### **2.3.11.1 Climate-Smart Agriculture in Kenya**

The Kenyan agricultural sector has experienced food shortages as a result of unfriendly weather conditions coupled with inadequate resources (Fleming *et al.*, 2016). The agricultural system in Kenya is highly rain-dependent, making it very vulnerable to the adverse effects of changes in climatic conditions. As a result, productivity among farmers, especially the small-scale farmers, is declining. Farming is a significant source of employment in Kenya and because of that climate variability has affected not only agricultural productivity but also the income of many households. The adverse effects on productivity and income of households are reflected in the development among the farmers and poor households (Korir *et al.*, 2015).

Conservation agriculture is the primary CSA practice adopted in Kenya where farmers minimize soil disturbance to reduce soil erosion. In Kenya, soil erosion is caused by deforestation and poor cultivation across the slopes. Frequent floods have forced many farmers to embrace minimum tillage of land (Kitsao, 2016). Also, the Kenyan government is advocating for the adoption of agroforestry among farmers to curb deforestation (Kitsao, 2016). Many small-scale farmers are adopting crop rotation and mulching. However, livestock feeds are competing with the use of grasses as mulch (Giller *et al.*, 2009).

### **2.3.11.2 Climate-Smart Agriculture in Rwanda**

Climate change has resulted in a shortage of resources such as food and water in Rwanda (World Bank, 2015). The rise of GHGs has led to instability in climatic conditions and inconsistent weather patterns. Yu *et al.* (2011), states that GHG emission in Rwanda is low when compared to other countries and this is attributed to the increase of livestock manures, land use and forestry activities. Rwanda is highly dependent on rain for agricultural activities making small-scale farmers to be profoundly affected by climate change. Floods and inconsistent rainfall have resulted in many losses in the agricultural sector.

The Rwandan government is assisting farmers by formulating and implementing policies that will allow them to have access to land. Farmers are also organized into groups for easier access to information that can help them in coping with climate change issues and in adopting CSA practices (Thornton & Herrero, 2014). Part of the efforts to facilitate the adoption of CSA is the implementation of gender equality in land ownership and the provision of clear directions on techniques that are beneficial to the farmers and the ecosystem. Farmers are also provided with crop seeds that can withstand harsh climate changes, and they are encouraged to embrace

soil conservation. Practices like crop rotation and intercropping are also advocated to improve soil fertility and food production (Isaacs *et al.*, 2016). Ya-Bititi *et al.* (2015) reveal that small-scale farmers in Rwanda were doing well in CSA adoption and attributed that to reasonable access to infrastructure, credit facilities and input services.

#### **2.3.11.3 Climate-Smart Agriculture in Malawi**

Malawi is one of the least developed countries in Africa seriously affected by harsh climatic conditions. In 2014, Malawi had an estimated population of 16.82 million with about 50.7 per cent living below the poverty line (World Bank, 2014). Agriculture is responsible for about 30 per cent of the GDP of the country (FAO, 2014). However, the poverty level in the country is deteriorating and the adverse climatic conditions such as floods and drought are critical contributors to the deterioration (World Bank, 2014). Women are noted to be most affected by climate variability due to their responsibilities within the households (Kitsao, 2016). Climate-smart agriculture has been embraced by policymakers to facilitate climate change mitigation and enhance food security (Kitsao, 2016). There are efforts from the government, non-governmental organizations and donors to reinforce the resilience of small-scale farmers to changes in climatic conditions by promoting CSA practices such as conservation agriculture, agroforestry and providing farmers with crop varieties that have a high tolerance to drought (Murray *et al.*, 2016).

#### **2.3.11.4 Climate-Smart Agriculture in Uganda**

A study by Jassogne *et al.* (2013) reveal that farmers in Uganda plant shade trees to protect their coffee crops. The planting of shade trees can influence the micro-climate and cause a reduction in the temperature of growing areas by about 2 – 5°C. The shade trees yield up to about 50 per cent additional income for the farmers. They also absorb carbon from the soil, reduce temperature and alleviate drought problems. In addition to the planting of shade trees, farmers adopt other CSA practices like intercropping and mulching.

#### **2.3.12 Small-Scale Agriculture in Sub-Saharan Africa**

Small-scale agriculture has been defined in different ways. Wiggins (2009) describes it as a process whereby farmers with a considerable level of knowledge of agriculture, cultivate small plots of land effectively. Earles (2015), however, does not focus on land size in his definition of small-scale agriculture as the use natural methods that involve food production without the

depletion of earth's resources or environmental degradation. Kutya (2012) examines small-scale agriculture from the perspective of carrying out crop or livestock production on family-owned pieces of land, traditional land and smallholdings on the periphery of urban areas. Kutya (2012) and Earles (2015) focused on the practice whereby farmers make food available for themselves and households through environmental sustenance.

Wiggins and Keats (2013) reveal that the agricultural systems in the developing world are primarily based on small-scale farms. Small-scale agriculture accounts for about 80 per cent of all farms found in Sub-Saharan Africa, claiming about 90 per cent of farming activities in some countries (Wiggins & Keats, 2013). Although there is no conceptually fixed definition of small-scale agriculture, in most instances where it is possible to quantify, it is vivid that most agricultural activities in many African countries are on a small-scale basis (Gollin, 2014). For example, most crop farms are smaller than five hectares, and reports from different household surveys in most countries with available data, for example, Botswana, Namibia, Democratic Republic of Congo, Ethiopia, Togo and Senegal established the likelihood of the median size of a crop farm to be between one and two hectares (Eastwood *et al.*, 2010; Simelane, 2017).

Agricultural production on a small-scale involves crop cultivation and livestock production on a small plot of land, which is primarily carried out through crude techniques and implements (Kutya, 2012). The use of the size of farmland as the basis for definition when explaining small-scale farmers or small-scale agriculture has been a source of debate. This is because it differs from place to place and in some instances, from crop to crop. However, Kutya (2012) argue that agricultural production on traditional lands, portions of land belonging to the family, smallholding farms in urban settlements come under small-scale agriculture.

The attribution of small land size to small-scale agriculture should not conceal the significant role and potential of the small-scale farming system in combating poverty and food security. The small-scale farming system does not only provide employment but also serves as source of food and sustenance for many rural dwellers (Gollin, 2014). Despite the considerable heterogeneity found across African countries, produce from small-scale farms account for a large proportion of the food consumed within households (Gollin, 2014).

More often than not, small-scale agriculture is characterized by intensive labor, animal traction, limited use of agrochemicals and the supply of produce to local markets (Earles, 2015). It is often viewed as backward and non-productive subsistence farming found in many rural parts of sub-Saharan Africa (Kutya, 2012). Although there are several small-scale agricultural

practices, they share common attributes. Small-scale agriculture is often found among vulnerable groups of developing and under-developed countries. Tshuma (2014) points out that small-scale agriculture is commonly practised at a local level by household members, mostly women and the elderly to provide food and generate income. Therefore, they rely on family labor and resources for food production and their livelihoods.

According to Tshuma (2014), small-scale agriculture is dominated by low-income groups who focus on subsistence farming or integrate subsistence and cash crops. They entirely provide self-service for subsistence production. In most cases, farmers involved in small-scale agriculture despite having a considerable level of knowledge about farming, are limited in the use of advanced and expensive technologies. This could be attributed to limited resources, education and sophisticated skills. Small-scale agriculture, to a large extent, operates on traditional know-how that competes based on low prices (Earles, 2015).

Despite the attributes as mentioned earlier and limitations of small-scale agriculture, studies have pointed out that small-scale agriculture contributes to food security and poverty alleviation (Gollin, 2014; Msangi, 2014). Gollin (2014) identifies small-scale agriculture as a key player in agricultural and rural development in many Sub-Saharan African countries. Msangi (2014) points out that a lot of developing nations, including South Africa, are beginning to focus on small-scale agriculture as a way to combat food insecurity and rural poverty. This could be achieved by empowering the sector to create more employment and stimulate rural development. Simelane (2017), however, argues that the potential of small-scale agriculture to combat food insecurity and alleviate poverty is being underutilized and therefore advocates for more empowerment of small-scale farmers.

However, despite the promise, small-scale farmers are highly susceptible to climate change and variability. Changes in climatic conditions have placed so many constraints on the utilization of land and water resources. This affects agricultural production from the small-scale agricultural sector since they are highly dependent on the resources for their production (Pillay, 2016). The FAO (2016) reports that extreme weather conditions have exacerbated disruptions to crop production on small-scale farms, stating that 226 583 small-scale farms in South Africa are affected by drought.

The vulnerability of small-scale farmers to climate change and variability highlights the need for innovation. Despite the unstable precipitation, small-scale agriculture is still majorly dependent on rain (Pillay, 2016). In addition to unpredictable rainfall patterns, frequent run-off

and soil erosion lead to the deterioration of farmlands (FAO, 2016). Climate-smart agriculture could avail small-scale farmers the opportunities for improving soil productivity and mitigating risks from climate change.

### **2.3.13 Farming System in South Africa**

The agricultural sector in South Africa accounts for about 10 per cent of total employment in the country and 33 per cent of export (Calzadilla *et al.*, 2014). Agriculture in South Africa is often perceived as a thriving sector. South Africa has a dual agricultural economy, which comprises of well-developed subsistence farms and small-scale subsistence farms. The commercial farms are capital intensive and export oriented, accounting for about 90 per cent of the country's agricultural production. Small-scale subsistence farms, on the other hand, are more labor intensive and they depend on traditional methods of production employing about 86 per cent of the country's farm labor force (Calzadilla *et al.*, 2014).

There is an ecological cost attached to food production, and the poor sustainability of the farming system in South Africa is attracting a growing concern (Van der Laan *et al.*, 2017). Despite the significance of small-scale farming system in the South African agricultural sector, the large scale-commercial agriculture dominates the food production system (Greyling, 2015). One of the challenges of the farming system in South Africa is the how to remove the structural constraints inhibiting the growth of the small-scale production system.

South Africa has a total land area of 122 million ha and uses about 13 per cent for farming. The commercial farming sector claims about 14 million, while the small-scale farming sector claims only 1.3 million ha with 2.9 million households practising farming at the subsistence level (Van der Laan *et al.*, 2017). The small-scale farming sector is characterized by low input – low production system. About 1.3 million ha of land in South Africa is under irrigation, accounting for 1 per cent of the 13 per cent under cultivation. Food insecurity remains widespread in South Africa with the ever-growing population placing greater pressure on the farming system (Musvoto *et al.*, 2014).

## **2.4 Analytical Framework**

The analytical technique employed in a study is a function of the nature of the study, type of data collected, purpose for which the model in the study is to be estimated, convenience of analysis and other econometric considerations. Studies on the effect of climate change on

agricultural production used the Ricardian Model to capture climate variables such as precipitation and temperature to examine how climate change impact crop and livestock production. In Ricardian Model, net revenue or land value are used as the dependent variable, while temperature and precipitation, with some other variables are used as the predictor variables. The Ricardian Model has been used to examine the sensitivity of agriculture to changes in climatic conditions (Blignaut *et al.*, 2009; Seo *et al.*, 2009; Arakelyan *et al.*, 2017).

This study, however, is not focusing on the impact of climate change on agricultural production but the effect of climate-smartness on agricultural production and food security. The literature has established changes in climatic conditions in South Africa (Ncube *et al.*, 2016; Tibesigwa *et al.*, 2017). This study highlights CSA adoption with socio-economic characteristics as drivers and inhibitors of agricultural production and food security. The study extends beyond CSA adoption to examine CSA adoption level and the factors influencing it. The analytical approaches commonly used in adoption studies involving multiple choices are the multinomial logit, multinomial probit, ordered probit and ordered logit, among others. Both the multinomial logit and multinomial probit are widely used for analyzing adoption/adaptation decisions. However, to accommodate hierarchical categorization of choices or adoption/adaption decisions, ordered logit and ordered probit are considered suitable (Green, 2012). As a novelty approach, this study used a multivariate choice econometric model to examine the relationship between a set of explanatory variables and different levels of CSA adoption. Hence the use of generalized ordered logit model, based on the violation of parallel regression assumption.

The advantage of using ordered logit model as opposed to univariate technique is that it controls for potential correlation among adoption/adaptation options. As a result, it provides more accurate estimates of relationships between adoption/adaptation level and its explanatory variables. On the other hand, the univariate technique is prone to biases caused by common factors in situations where there are unobserved and unmeasured common factors affecting the different levels of adoption/adaptation (Otitoju, 2013). Furthermore, ordered logit model is preferred over ordered probit model because it is easier to compute (Green, 2012). The limitation with the use of ordered logit model is that it must not violate the assumption of parallel regression assumption. The limitation with the violation of assumption of parallel regression assumption is taken care of in the generalized ordered logit model (Green, 2012).

The study also examines the effect of CSA adoption on household food security. The household food security status is captured as a binary outcome, which is the dependent variable for the

analysis. The analytical approaches used for bivariate dependent variables are logit, probit and linear probability models, among others. A logit model is preferred above probit and linear probability model because it has a simpler structural form and it is easier to interpret its outcome (Green, 2012). The analytical techniques for analyzing household food security include HDDS, HFCS and cost of calorie measure, among others. The HDDS is a qualitative recall of the food consumed within the period of 7 days (Wekesa *et al.*, 2018). The HDDS is preferred as the proxy for food security measure because it has a high correlation with factors such as households' intake of calories, protein and other nutrients (Mango *et al.*, 2014). It also reveals the extent to which there is variety in food consumption of the household. However, with the use of HDDS, it is difficult to conduct an empirical evaluation of nutrient adequacy. It does not analyze the quantities of food consumed in the household (Ogundari, 2017). The HFCS is used as a supplementary approach to support the HDDS. The HFCS aggregates the frequency of consumption of food items.

## **2.5 Chapter Summary**

This chapter presented the theoretical framework underpinning this study, review of literature on climate change, CSA and small-scale agriculture, and the analytical framework relevant to the study. The chapter begins by discussing the three theoretical concepts adopted in the study – the utility theory, the production theory and the food security model. It was explicitly stated that in explaining the utility theory, what is deemed necessary about utility concerning choice/s being made is whether an option has a higher utility than another rather than the measure of the difference between the available options. Most empirical studies on efficiency and productivity hang on the framework provided by the economic theory of production. The two basic approaches in estimating efficiency are the frontier approach and the classical approach. The food security model has four important components, which are availability, accessibility, utilization and sustainability. Availability implies there is food in a large quantity; accessibility means being able to acquire the required quantity; sustainability explains consistency in the access to food, and utilization relates to food quantity and quality at a sufficient level.

The chapter also explains the concept of climate change. The chapter showed the pattern of climate change in Sub-Saharan Africa and narrowed it to South Africa. Furthermore, the chapter discussed the perception of South African farmers of climate change and how climate change influences agriculture. It is clear from the literature that climate change is currently one of the most pressing issues facing the world today although it is not a new problem and it is

expected to accelerate in the foreseeable future. There is however a paradigm shift in the discourses of climate change leading to the increased involvement of public authorities in the management of the challenges posed by climate change. Sub-Saharan Africa in general and its agricultural sector in particular, is highly susceptible to climate change, and South African farmers are aware of increased temperatures and the decline in rainfall or precipitation.

The vulnerability of small-scale farmers to climate change and variability highlights the need for innovations such as those offered by CSA to achieve the goals of improved productivity, reduction in GHG emission and enhanced adaptation to changes in climatic conditions and the impacts. It can be concluded from the literature that climate change awareness is crucial for the successful mainstreaming of climate change adaptation and mitigation. Farmers in developing countries, considering their vulnerability, are the right targets to be educated about climate change and its effects. Also, CSA practices could be incorporated into a single farming system which can improve the livelihoods and incomes of farmers, mainly small-scale farmers. However, there is the need for more studies on what could influence the adoption of CSA among small-scale farmers. Also, there is the need for more studies on the resultant effect of CSA adoption on agricultural productivity and food security for successful mainstreaming of CSA, especially in the small-scale agricultural sector.

The chapter also presented the analytical approaches used in adaptation/adoption studies. The analytical approaches commonly used in adoption studies involving multiple choices are multinomial logit, multinomial probit, ordered probit, ordered logit, among others. The ordered logit was used in this study to accommodate hierarchical categorization of adoption/adaption decisions, and its ease of computation. Based on the violation of parallel regression assumption, the study used generalized ordered logit model. The analytical approaches used for bivariate dependent variables are logit and probit, among others. A logit model is, however, preferred for the study because of its simpler structural form and ease of interpretation of outcome. The analytical techniques for analyzing household food security include HDDS, HFCS and cost of calorie measure, among others. The HDDS is preferred as the proxy for food security measure because it reveals the extent to which there is variety in food consumption of the household. The next chapter presents the research methodology of the study.

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## CHAPTER THREE

### RESEARCH METHODOLOGY

#### 3.1 Introduction

To achieve the purpose of this study, it is important to comprehend the peculiarities of the study area and to adopt suitable research and analytical methods. Research methodology is crucial as it influences the reliability of the study's findings. This chapter provides details on the research methods including the study area, research philosophy, approach and the research design of the study. More importantly, the chapter also presents empirical models used for the analysis of the objectives of the study. The chapter is divided into sections for a logical presentation.

#### 3.2 Selection and Description of the Study Area

This study was conducted in King Cetshwayo District Municipality (KCDM) of the KwaZulu-Natal (KZN) province of the Republic of South Africa. KwaZulu-Natal is located in the east of South Africa and lies approximately between 27° and 31° latitudes south, and 29° and 31° longitudes east (Google Map, 2018). The province is bordered by the Indian Ocean in the east and by the Drakensberg Mountains and parts of Lesotho in the west. It also shares parts of its borders with Mpumalanga Province, Swaziland and Mozambique to the north, and the Eastern Cape Province to the south (Google Map, 2018). KwaZulu-Natal province covers a total area of 94 361km<sup>2</sup> representing 7.7 per cent of South Africa's total land area (Statistics South Africa, 2014). The largest city in the province is Durban and the capital is Pietermaritzburg. The province has one metropolitan municipality (eThekweni Metropolitan Municipality) and ten district municipalities, which are broken down into 43 local municipalities. Other prominent cities and towns in the province include Newcastle, Richards Bay, Ladysmith and Port Shepstone.

The study area was selected using the multi-stage sampling technique. In this regard, KZN was purposively selected for this study because of its record of high agricultural production and the presence of a substantial proportion of small-scale farmers compared to other provinces. KwaZulu-Natal has the highest number of farming households in South Africa (Lehohla, 2016). The next stage involved the random selection of KCDM. A random selection was employed to give every district municipality an equal chance of being selected. Subsequently, uMhlathuze and Mthonjaneni Local Municipalities were purposively selected based on their

agricultural potentials out of the five local municipalities within King Cetshwayo District, the other municipalities being Nkandla, uMfolozi and uMlalazi. uMhlathuze Local Municipality has an agricultural sector with the lowest economic contribution (3.2%) while Mthonjaneni has the highest (33.5%) (Municipal Directory of South Africa, 2017). The rationale for selecting the lowest and highest performing local municipalities in terms of their agricultural economic contribution is to allow for a comparative study of the effects of CSA on the food security status of small-scale farming households. Villages in the two selected municipalities were sampled based on the records from the Department of Agriculture and Rural Development (DARD) from each municipality. The records provided information on accessibility and availability of small-scale farming households in adequate number. Figure 3.1 is a map showing KCDM and its local municipalities.

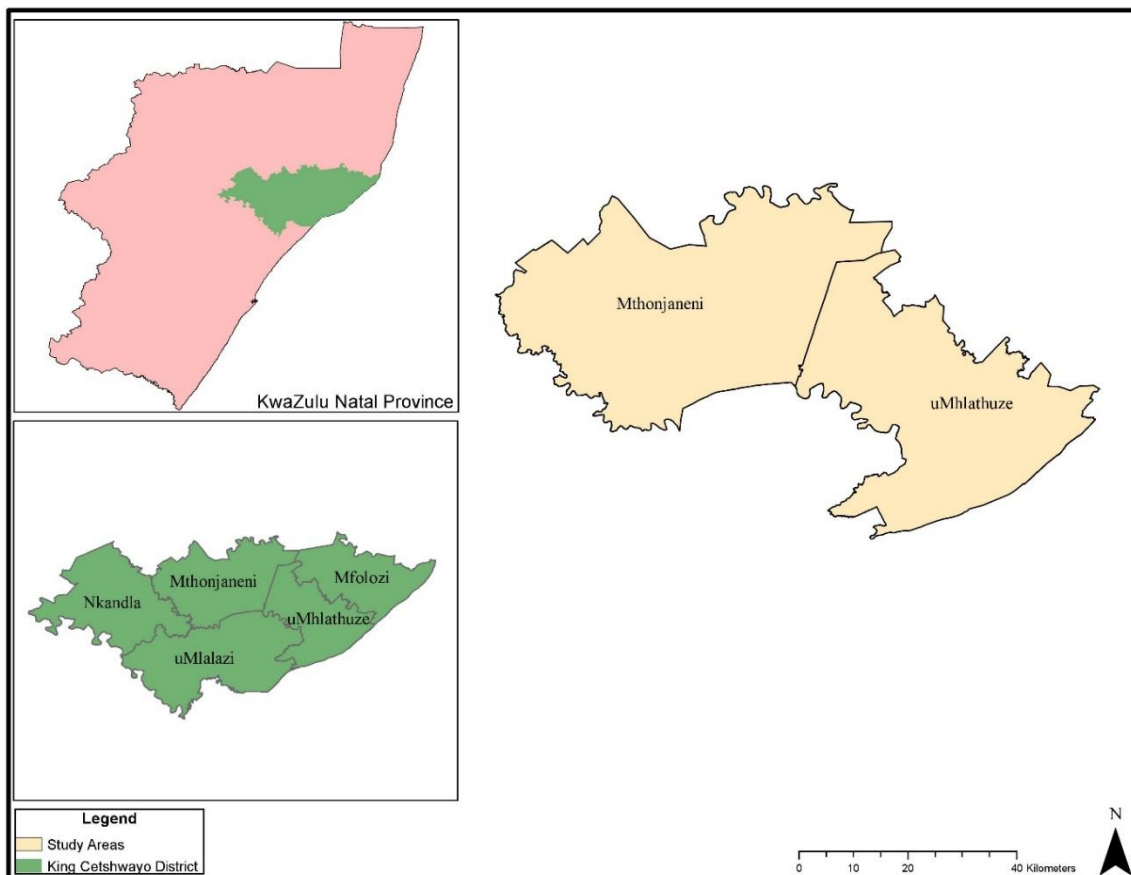


Figure 3. 1: Map showing KCDM and its local municipalities  
Source: Municipal Directory of South Africa (2017)

### 3.2.1 Geophysical Aspects

This section describes the topography, climate, temperature and vegetation of the study area.

### **3.2.1.1 Topography**

There are three distinct geographic areas in KwaZulu-Natal; the lowland region, which is along the Indian Ocean drift; the central Natal Midlands comprising an undulating hilly plateau ascending towards the west and two mountainous areas made up of the Northern Lebombo and Western Drakensberg mountains (Tourism KwaZulu-Natal, 2016). Owing to the topography in KZN, agriculture in the province is quite diverse. Most of the world's agricultural activities are practiced in KZN (KZN Top Business, 2017). This suggests why there is a high proportion of small-scale farming households in the province and therefore motivates the choice of the province for the study.

### **3.2.1.2 Climate and Rainfall**

KwaZulu-Natal's climatic condition is varied yet verdant (Kruger, 2014). Generally, the coast is subtropical with inland regions becoming progressively colder. The coastal climate is moderate and ranges from warm to sub-tropical temperatures (Kruger, 2014). The climate of the region is significantly influenced by the mild Agulhas current which gives it a humid sub-tropical feature. The province experiences relatively high rainfall, for the most part in summer, however, with an indistinct dry season in winter (Kruger, 2014). KwaZulu-Natal Department of Economic Development Tourism and Environmental Affairs, KZN EDTEA (2017) reports an annual rainfall of between 1000 to 1200mm with some areas, especially in the north coast, experiencing more than 1200mm annually. Much of the rainfall is in mid-summer although the winter period is not dry. About 28 days in a year receives more than 10mm of rain over a 24-hour time frame. These conditions are conducive for agricultural activities compared to other provinces in the country and there is high dependence on rain-fed agriculture but with the experience of high land degradation. This suggests a degree of vulnerability which could influence agricultural productivity and in turn the food security level of the farming households (Gbetibouo *et al.*, 2010; Kruger & Nxumalo, 2017).

### **3.2.1.3 Temperature**

The province has a monthly average temperature of 11 to 28<sup>0</sup>C, with daily temperatures during winter ranging from 16 to 25<sup>0</sup>C and 23 to 33<sup>0</sup>C during summer (KZN EDTEA, 2017). Temperatures could be uncomfortably high as a result of frequent high levels of humidity. Consecutive days with average daily temperature below 5<sup>0</sup>C, often tagged cold spells, are not frequent in the region. The relatively warm climate of the province gives it a comparative

advantage for agricultural activities. This serves as encouragement for small-scale farmers, thereby a high population of small-scale farmers in the province.

#### **3.2.1.4 Wind**

The KZN coastal region has a moderate wind regime with the spring north-east winds dominant in the spring and summer, while southwest winds dominate autumn and winter. The average daily record of wind speed is about 14.7Kph with wind speeds peaking during spring and ebbing during winter (KZN EDTEA, 2017). This provides fairly good conditions for agricultural production also (KZN Top Business, 2017).

#### **3.2.1.5 Vegetation**

The coastal regions of the province typically have subtropical thickets and deeper ravines, the northern part hosts a wet savannah habitat, the midlands have moist grasslands and isolated pockets of Afromontane Forest, while there is an abundance of alpine grassland in the Drakensberg region (Tourism KwaZulu-Natal, 2016). The vegetation in the province is a product of the relatively friendly climate which is fairly accommodating to agricultural activities. This relates to the relatively high level of agricultural activities reported to be taking place in the province when compared with other provinces (Statistics South Africa, 2014).

### **3.2.2 Socio-economic Characteristics**

Below is a brief summary of the socio-economic characteristics of the province.

#### **3.2.2.1 Population and Population Density**

The province has a total estimated population of 11 067 500 persons per 94 361 square kilometers, giving a population density of 117.3 and making it the province with the highest population in South Africa after Gauteng (South African Market Insight, 2017). This also allows for sufficient and adequate farming households which confirms the report published by Statistics South Africa (2014) stating that KZN accounts for the largest percentage of agricultural households in South Africa and a high proportion of small-scale farmers. This motivates the choice of the province for this study.

### **3.2.2.2 Educational Levels**

Eight districts out of the eleven districts in KZN had more than 90 per cent of children aged between 6 and 13 years enrolled in school in the last census (2011) conducted in South Africa (Statistics South Africa, 2014). About 11 per cent of those aged 20 years or more have no formal education, about 5 per cent have tertiary qualifications while about 30 per cent had a matric qualification in 2014 (Statistics South Africa, 2014). This suggests that a high proportion of farmers have one level of formal education or the other which could influence their approach to agricultural activities, CSA and possibly their agricultural productivity.

### **3.2.2.3 Employment Levels**

This study conceptualizes employment as legal activities that provide earnings or serves as a source of livelihood for those engaged in them. An overview of the labor market in KZN reveals that about 38 per cent of the population in the province that falls within the working-age range was employed in 2015, as against an average of 40 per cent at the national level (The Real Economy Bulletin, 2016) with an additional 200 000 employed in 2010 even when national employment rate fell following the 2008/9 global financial crisis. In 2014, the median wage for formal workers was ZAR 3 050, while the median wage for informal workers in the agricultural sectors as well as domestic workers was ZAR 1 300. These are well above the South African national poverty line which was ZAR 942 in 2014 (Statistics South Africa, 2019). About 63 per cent of the overall employment in KZN was in the formal non-agricultural sector. The estimate for this at the national level was about 69 per cent. The level of employment catered for by the agricultural sector could increase with higher levels of productivity if the sector embraces CSA practices.

### **3.2.2.4 Economic Activities**

The Real Economy Bulletin (2016) reports that KZN contributes significantly to the country's manufacturing and agricultural sectors as it hosts a port and the main North-South freight corridor. The province contributes 25, 22, 19 and 3 per cent to the national agricultural, manufacturing, construction and mining sectors respectively (The Real Economy Bulletin, 2016). Construction is experiencing the fastest growth in the main real economic sector of the province. In terms of the provision of employment, textiles and footwear, chemicals and plastic food and beverages, basic iron and steel, and paper and publishing are the five topmost in the manufacturing sector in the province. About 41 per cent of national employment in clothing,

textiles and footwear is from the province, but food and beverages contribute mainly to the province's growth in manufacturing jobs (The Real Economy Bulletin, 2016). The contribution of the agricultural sector to the economy of the province and in turn the economy of South Africa raises the need to address what could enhance the progress of the sector.

### **3.2.2.5 Agricultural Activities**

KwaZulu-Natal is the leading province in many agricultural products. It has the reputation of being the province that has more high-quality agricultural land area than other provinces (KZN Top Business, 2017). Despite covering a relatively small land area, it accounts for a substantial proportion of the small-scale farmers in South Africa. The province is known for its capability in diverse agricultural activities and has the potential to accommodate most of the world's agricultural activities. It has a total of 6.5 million hectares of agricultural land, 82 per cent of which is well suited to livestock production and 18 per cent to arable farming (KZN Top Business, 2017). Agriculture in the province is largely concentrated on crops such as maize and sugar cane, sub-tropical fruits such as bananas, pineapples and cashew, forestry such as poplar, South African pine, black wattle, saligna and eucalyptus, and livestock production such as poultry, sheep, beef and pigs (KZN Top Business, 2017). However, the level of dependence of agriculture on the climatic condition, especially rain-fed agriculture, makes small-scale agriculture in the province highly vulnerable to climate change (Pillay, 2016). This contributes to the motivation for the study and the choice of KZN as study area.

### **3.3 Description of Mthonjaneni Local Municipality**

Mthonjaneni Local Municipality covers a land area of 1 086 km<sup>2</sup> and has a total estimated population of 47 818 with a population density of 44/km<sup>2</sup> (Mthonjaneni Municipality, 2020). The municipality relies heavily on agriculture, mainly sugar cane, timber and cattle. Other fruits such as citrus and avocados are also produced for local and foreign markets. Mthonjaneni accounts for roughly 300 000 tons of sugar cane and 470 000 tons of timber annually (Mthonjaneni Municipality, 2020). Most communities in the municipality practice small-scale farming, the farming system incorporates a large tract of commercial farming as well. About 75 per cent of the labor force in the municipality are employed in the agricultural sector. The expansion of the local economy focuses on increasing timber and sugar cane production (Mthonjaneni Municipality, 2020).

### **3.4 Description of uMhlathuze Local Municipality**

uMhlathuze Local Municipality has a total land area of 1 195 km<sup>2</sup> with a population of 384 449, giving a population density estimate of 322/km<sup>2</sup> (uMhlathuze Municipality, 2020). The municipality is reported as the third economic hub in KZN and the fastest growing municipality in KZN. uMhlathuze has different economic sectors which comprises of mining, agriculture and manufacturing. Aside the areas of natural significance in the municipality, a large expanse of land in the area is used for commercial agriculture production. However, there are many households in the municipality engaging in small-scale farming. Agriculture contributes about 3.2 per cent to the economy of the municipality (uMhlathuze Municipality, 2020).

### **3.5 Research Philosophy**

Research philosophy addresses the source, nature and development of knowledge. Research philosophy explains the phenomenon on how data should be collected, analyzed and used (Saunders, 2011; Žukauskas *et al.*, 2018). There are four major types of research philosophy; positivism, interpretivism, pragmatism and realism (Žukauskas *et al.*, 2018). This study adopts the positivist research philosophy.

Positivism is an approach to social research which applies the natural science model of research in investigating and explaining social phenomena (Denscombe, 2009). Positivism embraces the idea that the methods and procedures of the natural sciences are applicable in social sciences. It builds on a conviction that the application of scientific principles cannot be hindered by people who are the objects of social sciences (Glicken, 2003; Žukauskas *et al.*, 2018). Positivism claims that social phenomena can be studied objectively. With positivism, scientists are objective analysts and based on that, they dissociate themselves from personal values and work independently (Žukauskas *et al.*, 2018). Positivism also rests on the belief that an objective reality exists outside of personal experience that has demonstrable and immutable laws and mechanisms that can reveal cause and effect relationships (Neuman & Kreuger, 2003; Bernard & Bernard, 2013). This study adopts positivism based on the central focus of the study, which is to determine the effect of CSA on the food security status of small-scale farming households in KCDM of KZN province of South Africa. The study conducts an objective explanation of the research objectives and rests on the conviction that the research respondents are not an obstacle to the research process.

### **3.6 Research Approach**

A research approach involves the philosophical assumptions that direct how data are collected and analyzed (Creswell & Creswell, 2017). There are two well-known and recognized approaches to research, which are the quantitative and qualitative paradigms. Each approach has its purposes, methods of conducting the inquiry, strategies of data collection and analysis, and criteria for judging the quality (Alasuutari *et al.*, 2008). This study adopts a quantitative research approach.

The quantitative research approach is generally associated with positivism. It usually involves the collection and conversion of data into a numerical form for statistical calculations and drawing of inference(s) (Bergman, 2008; Žukauskas *et al.*, 2018). Quantitative research is statistics-based. It addresses questions, basically, based on numbers. The numbers are then analyzed with statistical models to see what story the data is telling. Structured guidelines exist for conducting quantitative research. Concepts, variables, hypotheses and methods of measurement are defined for the research process (Alasuutari *et al.*, 2008; Žukauskas *et al.*, 2018). This study adopts a quantitative approach as it is best suited to answering questions about relationships among measured variables with the purpose of explaining and predicting outcomes and phenomena. The central focus of the study is to establish a relationship between CSA adoption and household food security, examining the effect of CSA adoption on the food security status of farming households. This serves as the rationale for adopting a quantitative approach that allows the use of econometric models.

### **3.7 Research Design**

A research design is the framework of techniques used in integrating the various components of a research study in a coherent and logical manner for efficient handling of the research problem (Kumar, 2014; 2019). It reveals the blueprint for collecting, measuring and analyzing data. A research design helps in ensuring that the evidence obtained during a research study is effective as much as possible to address the research problem in a logical and unambiguous manner (Bell *et al.*, 2018). This study adopts a cross-sectional research design which is used to find correlations between variables at a single point in time. It is useful for analyzing and drawing inferences from existing differences between people, subjects or phenomena. Cross-sectional research designs can employ data from diverse backgrounds of disciplines and

contrasting observational studies. It is comparatively less expensive to use and less time consuming (Akhtar, 2016; Creswell & Creswell, 2017).

The cross-sectional research design was considered appropriate for this study because it enables rational and sound conclusions and is both time and cost efficient. It will enable accurate investigation into the research problem to gain a better insight and familiarity into the prospect of CSA as it relates to productivity and food security in small-scale agriculture, even with time and money constraint. This study is empirical in nature and involves the use of a survey to gain insight into the research problem and to arrive at sound conclusions. This study utilizes both descriptive and inferential analytical techniques for robust conclusions. Figure 3.2 shows the blueprint followed in the cross-sectional research design. The study conducted a survey with a quantitative approach to arrive at findings with empirical backings.

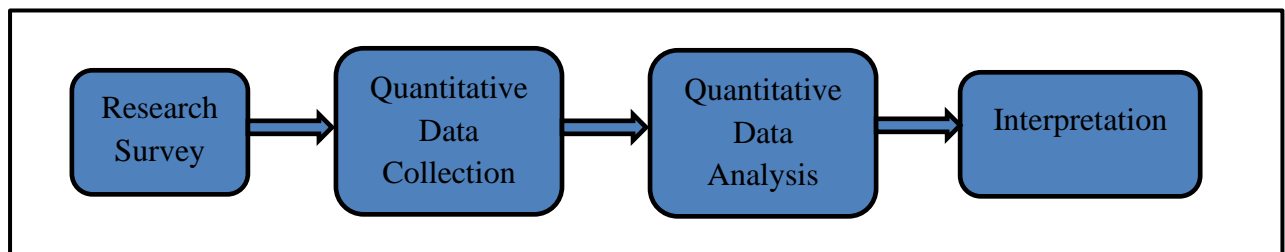


Figure 3. 2: Research design followed for the study  
Source: Author’s research design adapted from Akhtar (2016)

### 3.8 Conceptual Framework

This study adopts Kutya (2012) definition of small-scale agriculture as one that is carried out on family-owned land, traditional land and smallholdings. The study also borrows from past studies in viewing climate change as observable variations in climatic conditions which could be ascribed to human activities (Ajetomobi *et al.*, 2010; Bunce, 2010; Belaineh *et al.*, 2013). The study conceptualizes CSA as a climate change adaptation approach aimed at helping farmers adjust to climate change and to enhance their productivity while food security is defined as access to sufficient, healthy and nutritious food (FAO, 2013; Dooley & Chapman, 2014; Lipper *et al.*, 2014). The conceptual framework in Figure 3.3 illustrates the critical interactions between climate change, adaption to the change and agricultural productivity revealing the role of CSA in ensuring food security.

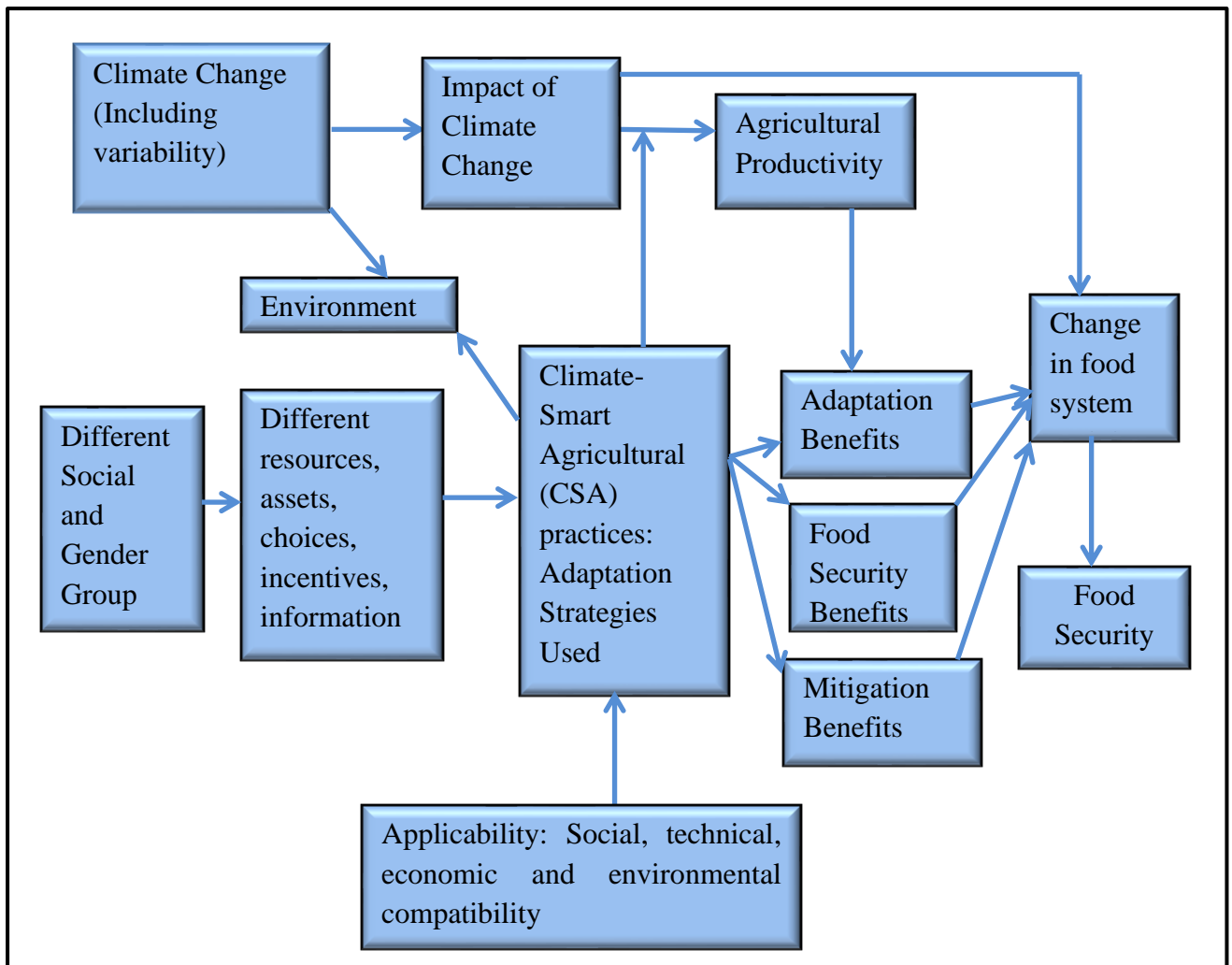


Figure 3. 3: Conceptual framework – The influence of CSA on agricultural productivity and food security

Source: Author’s conceptual design adapted from Greg *et al.* (2011); Belaineh *et al.* (2013)

Changes in climatic conditions have negative influences on food availability, stability, access and utilization. Climate change affects the availability of agricultural products directly by influencing crop pests and diseases, soil water-holding properties and fertility as well as crop yields. The indirect influence is through its effects on agricultural demand, income distribution and economic growth. The impact of climate change is expected to raise the prices of commodities, which can bring about a decline in food consumption, thereby worsening the problem of food insecurity (Kavallari, 2015). Although food demand is not very sensitive to price changes, the effect will still be felt, especially in areas where there are strains on natural resources (Kavallari, 2015). Climate change also brings about changes in food systems activities, which in turn affects food availability (Greg *et al.*, 2011).

Climate change adaptation can be influenced by various factors such as the different social and gender groups farmers belong to, the different resources, assets, choices, incentives and information on climate change at their disposal, the environment they belong to and their perceptions of climate change and climate variability. The adoption of CSA practices by farm households has a ‘triple-win’ benefit, which are food security benefits, adaptation benefits and mitigation benefits. The benefits accrue to farmers and the environment through improved productivity, reduction in GHG emission, enhanced adaptation to changes in climatic conditions and the impacts (Lipper *et al.*, 2014). All these benefits of CSA are anticipated to bring about the achievement of food security, which is the ultimate goal of CSA.

Climate change poses a significant threat to agricultural stability and productivity. Indices of climate change such as changes in patterns of temperature and precipitation are expected to modify production seasons, pest and disease trends and also change crop sets. The resultant effect of these is a change in food system activity, which in turn adversely affects security. There is, therefore, the need for adaptation and resilience and the ability to perform well in the face of disruption. This is where the CSA adoption becomes imperative. The adoption of CSA practices as a measure to handle the adverse impact of climate change on the agricultural system does not only offer adaptation and resilience to climate change impact but also the reduction or total elimination of GHG emissions.

The adoption of CSA mitigates the adverse effect of climate change on agricultural productivity, thereby enhancing food security. This study, therefore, conceptualizes the adoption of CSA practices as a determinant of food security under climate change. The study explores the different factors that could affect the adoption of CSA practices, among which are the social or gender groups of farmers as well as resource availability, incentives and exposure to information.

### **3.9 Study Population**

This study focused on the small-scale farming households in KCDM of KZN province in South Africa. Considerations were given to both crop and livestock farming households, and this is because climate change does not affect crop production alone but livestock production as well (Rojas-Downing *et al.*, 2017). By so doing, the information was gathered from both agricultural enterprises broadly related to small-scale farming in the study area/s.

### 3.9.1 Sample Size and Sampling Techniques

This study employed a multistage sampling technique. Multistage sampling is used for a survey when the population of the study is substantial, and the complete list of all the members of the population are not available. It is also used when there is the need for cost and time efficiency (Hahn, 2017). A multistage sampling technique divides large populations into stages to make sampling more practical.

Information obtained by the researcher from the DARD in uMhlathuze Local Municipality indicated that there are 8 villages in the local municipality namely, Bhejane, Dube, Madlebe, Mandlazini, Mkhwanazi, Obizo, Obuka, and Somopho with approximately 1 440 small-scale farming households known to the DARD. Mthonjaneni had the following 13 villages – Ebomuini, Edubeni, Ekuthuleni, Magwaza, Mfanefile, Mfule, Ndudulu, Njomelwane, Nkwenkwe, Sabiza, Sogawu, Thengele, and Yanguye, with approximately 720 small-scale farming households known to the department. This means that there are 2 160 small-scale farming households in the two district municipalities according to DARD’s records at the time of the study.

The sample size of 327 small-scale farming households was derived using a sample size calculator with a 95 per cent confidence level and confidence intervals of 5. Following Hoyle *et al.* (2002), further calculations were done to break down the sample size for each local municipality as follows:

uMhlathuze Local Municipality –  $n = (1440/2160) * 327 = 218$  small-scale farming households

Mthonjaneni Local Municipality –  $n = (720/2160) * 327 = 109$  small-scale farming households

Therefore, 218 small-scale farming households were derived from uMhlathuze and 109 from Mthonjaneni. A random selection of farming households was carried out from the selected villages to arrive at the stated sample size. A random selection gave every farming household an equal chance of being selected.

### 3.9.2 Data Collection

Data was collected from closed and open-ended questionnaires with detailed information for the descriptive and explanatory purpose and also inferential analysis that would reveal the cause and effect relationships in the objectives of the study. Focus Group Discussions (FGD) were conducted where necessary and applicable to get more insight into the data collected. Data was collected on the socio-economic characteristics of farmers (variables regarded as a set of farmers' characteristics include age, gender, household status, level of education and income), CSA practices, expenditure on food consumption, the yield from agricultural production among others.

A pilot study was carried out with 35 respondents in line with the recommendations made by Moore *et al.* (2011) and Connelly (2008) that 10 per cent of the actual sample size is suitable for a pilot study. The questionnaire was pre-tested for the adequacy, appropriateness and effectiveness of the questions. The time taken to complete the questionnaire was also noted during the pre-testing. The questionnaire was translated into isiZulu (the native language in the study area/s) for effective communication with the respondents and to be able to elicit relevant, credible and reliable information from them. The respondents from the pilot survey were excluded from the actual survey.

Before data collection, enumerators were adequately trained on the survey approach to achieve a result-oriented and productive survey. The enumerators were trained on research ethics, question-asking and probing skills to be able to get an excellent level of information-revealing responses from the participants. Also, they were trained on how to summarize lengthy responses from the respondents. As part of their training, the enumerators participated in the pre-testing exercise.

Information on agricultural production that was gathered from the respondents was for the farming season preceding the time of data collection to ensure uniformity, regularity and completeness of the dataset. Questionnaires were administered at the household level with the actual respondents being the person/ s responsible for household farming activities and those handling food preparation for the household if they are different individuals. This helped to get a robust response and quality information on the food security status of the household. The questionnaires were interviewer-administered to guard against misconceptions of words or questions. Data were collected between August 2018 and January 2019, during working hours

(08h00-16h00) and the interview lasted up to 50 minutes on average. Ethical clearance for the study was issued by the University of Zululand before commencement.

### **3.10 Data Management and Analytical Framework**

All data collected was collated and coded on Microsoft Excel spreadsheet version 365 (Microsoft Corporation, Washington, USA). The research data were saved on the hard disk of the researchers' personal computer with a backup on the external hard drive and on cloud storage (Google Drive) to ensure safety and security of the data. The statistical packages used for data analysis are the IBM Statistical Package for Social Science (SPSS) version 24 (SPSS Inc. (IBM), Chicago, Illinois, USA) and STATA 14 (StataCorp, Texas, USA) software. The analytical tools used are Descriptive Statistics, Adaptation Strategy Use Index (ASUI), Acceptance Level Index (ALI), Composite Score, Total Factor Productivity (TFP), Ordinary Least Squares (OLS) regression model, HDDS, HFCS and Binary Logistic Regression Model.

#### **3.10.1 Descriptive Statistics**

Descriptive statistics were used to identify and assess the extent of use of CSA practices in the study area/ s. This includes the use of frequencies, percentages, means and standard deviation (expressed in graphs and tables) to describe the socioeconomic and demographic characteristics of the respondents as well as the CSA practices under consideration.

#### **3.10.2 The Adaptation Strategy Use Index**

To determine the extent of the adoption of CSA practices by small-scale farming households in the study area/ s, an ASUI was adopted. Farmers were asked to assess different CSA practices by using a four-point rating scale 3, 2, 1 and 0 to denote frequently used, occasionally used, rarely used and not used respectively. A detailed application of the ASUI in this study is discussed in chapter four (section 4.2.4\*).

#### **3.10.3 The Composite Score**

The composite score was used to determine the factors influencing the level of use of CSA practices by respondents. The composite score was computed from the responses of the farmers on the level of use of CSA practices. The farmers were then categorized into high, medium and low users based on their composite scores. A detailed application of the composite score in this study is discussed in chapter five (section 5.2.4\*).

### **3.10.4 The Generalized Ordered Logit Regression Model**

The Generalized Ordered Logit Regression (gologit) Model was used to determine the factors affecting the level of use of CSA by the small-scale farming households in the study area/ s. A detailed application of the generalized ordered logit regression model in this study is discussed in chapter five (section 5.2.4\*).

### **3.10.5 The Acceptance Level Index**

To determine the extent of the adoption of CSA practices by small-scale farming households in the study area/ s, an ALI was adopted. Farmers were asked to assess CSA practices by using a three-point rating scale 2, 1 and 0 to denote acceptable, neutral and not acceptable respectively. A detailed application of ALI in this study is discussed in chapter six (section 6.2.4\*).

### **3.10.6 The Total Value Product**

The TVP was used to capture the multiple outputs of the sampled farmers to analyze the effect of the level of adoption of CSA practices on the agricultural productivity of small-scale farming households in the study area/ s. A detailed application of TVP in this study is discussed in chapter seven (section 7.2.4\*).

### **3.10.7 The Ordinary Least Squares Regression Model**

The OLS regression model was used to examine the effect of using CSA practices on the productivity of the small-scale farming households in the study area/s. A detailed application of OLS regression in this study is discussed in chapter seven (section 7.2.4\*).

### **3.10.8 Household Dietary Diversity**

The study used HDDS as a proxy to measure household food security. FAO (2011) describes HDDS as a qualitative free recall of all food or drink that has been consumed by any household in a 24-hour period for 7 days. It is measured by adding the number of food groups under consumption over the reference period (Kassie *et al.*, 2008; Uraguchi, 2012). However, HDDS does not include an estimation of the quantity of food that is lacking because it cannot be used for direct quantification of the amount of food consumed (Mango *et al.*, 2014). A detailed application of HDDS in this study is discussed in chapter eight (section 8.2.4\*).

### **3.10.9 Household Food Consumption Score**

The HFCS is used as a supplementary approach to support the findings of HDDS. The HFCS is an aggregate of the frequency of consumption of food items based on food groups. The frequency obtained is weighted to the nutritional value of the food groups by multiplying the aggregate score from the frequency of consumption and its weighting. A detailed application of HFCS in this study is discussed in chapter eight (section 8.2.4\*).

### **3.10.10 The Binary Logistic Regression Model**

A binary logistic regression model was employed to determine the effect of using CSA practices on the food security status of respondents. The food security status (food secure/food insecure) of the household was used as the dependent variable, while the composite score on the adoption of CSA practices and other hypothesized variables were the predictor variables. A detailed application of the binary logistic regression model in this study is discussed in chapter eight (section 8.2.4\*).

### **3.11 Limitations of the study**

This study could not be conducted as a time series study or adopt a panel study approach due to the constraints of time and money. However, a cross-sectional research design was adopted with sophisticated statistical models to minimize bias and error in analyzing data collected. Furthermore, the study could not conduct a simple random sampling of the small-scale farming households in KZN, considering the vast amount of small-scale farming households in the province. However, the multi-stage sampling technique was used for representativeness which means this study is only representative at the municipality level and cannot be generalized at the national level. Total value product was used as a proxy measure for productivity in analyzing the effect of CSA adoption on agricultural productivity. The use of TVP does not take into account input usage in analyzing farm productivity. This study used HDDS as a proxy measure of food security, which captures only the qualitative aspect of food security in terms of diversity of food consumption according to food groups. However, HFCS was used as a supplementary approach to support the findings from HDDS.

### **3.12 Ethical considerations**

This study met the research and safety standards of the University of Zululand. Since the study involved human participation, the dignity of respondents was recognized. The following ethical obligations were also taken into consideration:

#### **3.12.1 Rules Compliance**

The researcher endeavored to abide by the university's policies and requirements as stated in its policies. The researcher sought permission where necessary and adhered strictly to the copyright act which is quite important to this study. References were accurate in line with the reference guide approved by the research supervisor/ s.

#### **3.12.2 Informed Consent and Voluntary Participation**

The right to decide whether to participate in a study or not, or to pull back at any phase of a study was respected in the course of this study. Respondents were requested to sign informed consent forms before they took part in the research. This was done so that the respondents could show their willingness to be involved in the study having understood the objectives of the research, how data accumulated will be utilized, and the risks involved. Considering the probable vulnerability of research respondents, at whatever point a respondent did not have the ability to make an informed choice to participate, a proxy was identified by the investigator to settle on a decision for them. The proxy could be the spouse, a family member or close relative.

#### **3.12.3 Privacy and Confidentiality**

The right to privacy and confidentiality was respected as information gathered in the study was not revealed to any third party and was used exclusively for the purpose of this study. The questionnaires were anonymous, and names were not revealed in data analysis or report writing.

#### **3.12.4 Language and Cultural Considerations**

Every community has a set of norms and values that depict their culture and identity as a people. Regard for cultural values and norms enhances the integrity and credibility of data collected and the chances of a successful study (Canagarajah & Stanley, 2015). Therefore, adequate attention was given to culture, language, beliefs, perceptions, customs, age, and gender. As indicated earlier, the questionnaire was translated into the local isiZulu dialect, and research

assistants were enlisted from qualified locals who understood the ways of life and customs of the people in the study area/ s.

### **3.12.5 Recognition of Local Authorities**

Local authorities in the study area have to be respected (Canagarajah & Stanley, 2015). The local authorities are also beneficiaries of the findings from the study, so the researcher acknowledged their presence and sought their permission to conduct the study in their area. Courtesy calls were made to the local municipal authorities. During these visits, the researcher explained the aim of the research, the procedure of the research, and how its findings will support policy formulation and decision making.

### **3.12.6 Carefulness**

A researcher should endeavour to guide against carelessness, as well as negligence and keep good records of research activities (Canagarajah & Stanley, 2015). Therefore, the researcher made a good effort to ensure the data collected are kept safely. The researcher also ensured that there was backup storage for the collected data.

### **3.12.7 Integrity**

Integrity is crucial to a successful study (Creswell & Creswell, 2017). The researcher endeavoured to guard against bias in data collection, analysis and interpretation. The researcher also sought to work with integrity in other aspects of the study.

### **3.12.8 Honesty**

Honesty in research enhances the quality and reliability of the study. The researcher endeavoured to avoid fabrication, falsification and misrepresentation of data. The researcher adequately acknowledged resources that were consulted for the study.

## **3.13 Chapter summary**

This chapter described the research methodology of the study and outlined the research philosophy, approach and design. The description also covered the sampling methods used, methods of data collection and analytical techniques. The study was conducted in KCDM of KZN province, South Africa. It adopted a positivist research philosophy and quantitative research approach. The research design is cross-sectional, enabling rational and sound

conclusions despite time and resource constraints. A multi-stage sampling technique sampling was used to arrive at a sample size of 327. Data was generated with the aid of a structured questionnaire from 327 small-scale farmers in the study area. Two local municipalities (Mthonjaneni and uMhlathuze) were selected for comparison from King Cetshwayo District based on their agricultural potential. The data collected was compiled on Microsoft Excel spreadsheet version 365 (Microsoft Corporation, Washington, USA) and analyzed using the IBM Statistical Package for Social Science (SPSS) version 24 (SPSS Inc. (IBM), Chicago, Illinois, USA) and STATA 14 (StataCorp, Texas, USA) software. The analytical techniques used include ASUI, ALI, HDDS, HFCS, Composite Score, Generalized Ordered Logit Regression, Ordinary Least Squares Regression and the Binary Logistic Regression Model. Ethical issues were also highlighted in this chapter. They include rules compliance, informed consent and voluntary participation, privacy and confidentiality, language and cultural considerations, recognition of local authorities, carefulness and integrity. The subsequent chapters present the results of the study.

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## CHAPTER FOUR<sup>1</sup>

### THE EXTENT OF THE ADOPTION OF CLIMATE-SMART AGRICULTURAL PRACTICES BY SMALL-SCALE FARMING HOUSEHOLDS IN KING CETSHWAYO DISTRICT MUNICIPALITY

#### Abstract

Agricultural practices that fit into CSA profile helps in improving the adaptive capacity of farmers through the efficient use of available resources and creation of an agricultural system that will not collapse under the pressure of climate change. This paper used data collected from KCDM to assess the CSA practices adapted by small-scale farmers to cope with climate change. A multi-stage sampling technique was used for sample selection. Data were generated with the aid of a structured questionnaire from 327 small-scale farmers in the district, making a comparison between two local municipalities (Mthonjaneni and uMhlathuze) selected from the district based on their agricultural potential. The analysis made use of ASUI and descriptive statistics. Results show that the use of organic manure, rotational cropping and planting of drought and heat tolerant crops were reported by most (81%, 74% and 65%) of the sampled farmers, with an ASUI of 313, 289 and 249, respectively, as the popular CSA practices adopted for crop production. Concerning livestock farming, most (83% and 70%) of the sampled farmers with an ASUI of 116 and 104 reported improved grazing and efficient manure management, respectively, as the most common CSA strategies they adopted. With regards to mixed farming, most (87% and 83%) of the sampled farmers with an ASUI of 292 and 282 reported the use of organic manure and integrated crop-livestock management, respectively, as the most popular CSA practices. These findings reveal that the sampled small-scale farmers are already making efforts to survive the challenges of climate change. This paper argues that it is crucial to understand the pattern of adoption among small-scale farmers for a successful mainstreaming of CSA related projects and empowerment of small-scale farmers for sustainable agriculture under climate change. Involving small-scale farmers in program design will enhance successful mainstreaming of CSA in the small-scale farming system.

**Keywords:** Adaptation, climate-smart agriculture, small-scale, strategy, user index

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<sup>1</sup> N/B This chapter is prepared as an article for submission to an accredited journal.

\* Text that has already been explained in the methodology chapter will be skipped, with only reference given to.

## 4.1 Introduction

Agriculture has been a significant source of employment and vital for economic growth in many African countries (Williams *et al.*, 2015). There is a high level of dependence of rural households, both directly and indirectly, on agriculture for food and livelihood in Sub-Saharan Africa (Serdeczny *et al.*, 2017). Most rural households in Sub-Saharan Africa depend on small-scale agriculture for livelihood (Gollin, 2014). Sufficient food in households is viewed as an index of wealth and prosperity by dwellers of rural communities (Mngumi, 2016). With this in perspective, despite the pressure posed on agricultural production by climate change, rural farmers still strive to cope with being able to meet their livelihood needs. The changes in climatic conditions have forced farmers to change some of their farming practices or adopt different or new methods to be able to cope with the changing conditions of the climate (Otitoju, 2013; Serdeczny *et al.*, 2017).

Farmers adapt to climate change by adjusting through practices that could bring about the reduction of their vulnerability or the enhancement of their resilience in response to observed or expected changes in climatic conditions (Abraham, 2018). Adaptation takes place within physical, ecological and social systems (Abraham, 2018). Adaptation could be expressed through modifications of social and environmental processes, changes in perceptions of climate risks, adoption of practices or approaches that could bring about a reduction in potential damages or realization of and opening to new opportunities (Below *et al.*, 2015).

Responding to climate change in agriculture involves adjusting agricultural activities, especially management practices, to cope with shocks and the impacts of climate variability (Mngumi, 2016). Different studies have been conducted on the adaptation strategies and coping mechanisms of farmers in responding to climate change (Gandure *et al.*, 2013; Sani *et al.*, 2016; Abraham, 2018). In adapting to climate change, farmers adopt many practices which do not only help them adjust but also integrate the benefits of adaptation, mitigation and increased productivity (the triple win benefits), thereby fitting into CSA profile (FAO, 2014; Lipper *et al.*, 2014).

Agricultural practices that fit into CSA profile help to improve the adaptive capacity of farmers, mainly small-scale farmers, through the efficient use of available resources and creation of an agricultural system that will not collapse under the pressure posed by climate variability (Lipper *et al.*, 2014). Dooley and Chapman (2014) point out that farming households which

adopt CSA practices are expected to be better off than their counterparts which do not. The reason given revolved around the integration of the adaptation, mitigation and increased productivity which the concept of CSA offer (FAO, 2014; Kitsao, 2016).

The small-scale agricultural sector plays a vital role in providing food and employment in South Africa, especially for rural dwellers (Tshuma, 2014). About 20.7 per cent of the households in South Africa are engaged in farming, and 65 per cent of these farming households are small-scale (Republic of South Africa, 2014). However, the exciting potential of the small-scale agricultural sector in South Africa also has the challenge of climate change and variability to contend. Extreme weather conditions have facilitated severe loss to many small-scale farms in the country. About 226 583 small-scale farms have been reported to suffer significant damage from drought (FAO, 2016).

This paper investigated and assessed the practices which small-scale farmers in the study area adopted to cope with climate change, but practices which do not only help in climate change adaptation but based on their potential and benefits fit into the objectives of CSA. The adoption of CSA practices is a significant effort that can assist South African farmers in boosting their resilience to climate change and reduce emissions, thereby making CSA very relevant in the context of South African agriculture. However, the dearth of studies on CSA in the African context has been noted as a constraint in mainstreaming sustainable agriculture in the era of climate change (Wekesa *et al.*, 2018). Therefore, this paper provides information very relevant for closing the knowledge gap regarding this.

Climate-smart agriculture was recommended based on the idea that it will contribute immensely to agricultural development in this era (Lipper *et al.*, 2014; Lipper & Zilberman, 2018). Except CSA is adopted on a whole scale, and there is a successful mainstreaming of the concept into policy framework and programs, the food system and livelihood may collapse under the intense pressure of extreme and varying weather conditions (Onyeneke *et al.*, 2018). Since the aforementioned problem can give rise to a significant economic crisis, it becomes very imperative for governments and agricultural stakeholders to aggressively promote CSA activities at all levels. To be successful in this, it is crucial to examine and understand what obtains among the most vulnerable class in the agricultural sector; the small-scale farmers (Onyeneke *et al.*, 2018). This helps in mainstreaming policy frameworks and decisions designed on approaches which are inclusive of the actual targets.

## **4.2 Materials and Methods**

### **4.2.1 Study Area**

As earlier stated in chapter four of this thesis, the research study was conducted in KCDM of KZN Province of the Republic of South Africa. Refer to chapter three (section 3.2) for the detailed information on the description and selection of study area/ s.

### **4.2.2 Research Design**

A cross-sectional research design was adopted. Refer to chapter three (section 3.7\*) for the detailed information on the description and rationale of the chosen design.

#### ***Conceptual framework***

The main goal of CSA is a sustainable increase in agricultural productivity, climate change adaptation and reduction or total removal of GHG emissions (FAO, 2013; Lipper *et al.*, 2014). The concept of CSA in its framework aims to integrate these three goals to enhance agricultural productivity and food security under a changing climate (FAO, 2013). Alongside innovations and technologies that are harnessed towards the implementation of CSA, agricultural practices that fit into CSA profile have been identified as CSA technologies (Wekesa *et al.*, 2018). Therefore, this paper conceptualizes agricultural practices that have been identified to fit into CSA profile as CSA practices, and the level of adoption of these practices as the level of CSA adoption among the small-scale farmers in the study area/ s.

The adoption of agricultural innovations or technologies among farmers, mainly small-scale farmers, are not automatic; there are key players involved in the small-scale farming system. The characteristics of small-scale farmers coupled with CSA technological options and agents of information at the disposal of the farmers are factors to be considered in CSA implementation and adoption. Farmers' socio-economic characteristics play key roles in mainstreaming CSA in the small-scale farming system. Furthermore, the characteristics of CSA packages are critical to CSA uptake by farmers. As much as understanding the small-scale farming system in relation to the characteristics of the farmers making up the system is important, it is expedient to understand the characteristics of the CSA technologies available for uptake in the system. It is also important to understand how they can fit into the system. Figure 4.1 illustrates how this paper conceptualizes CSA adoption among small-scale farmers and how CSA adoption can be influenced.

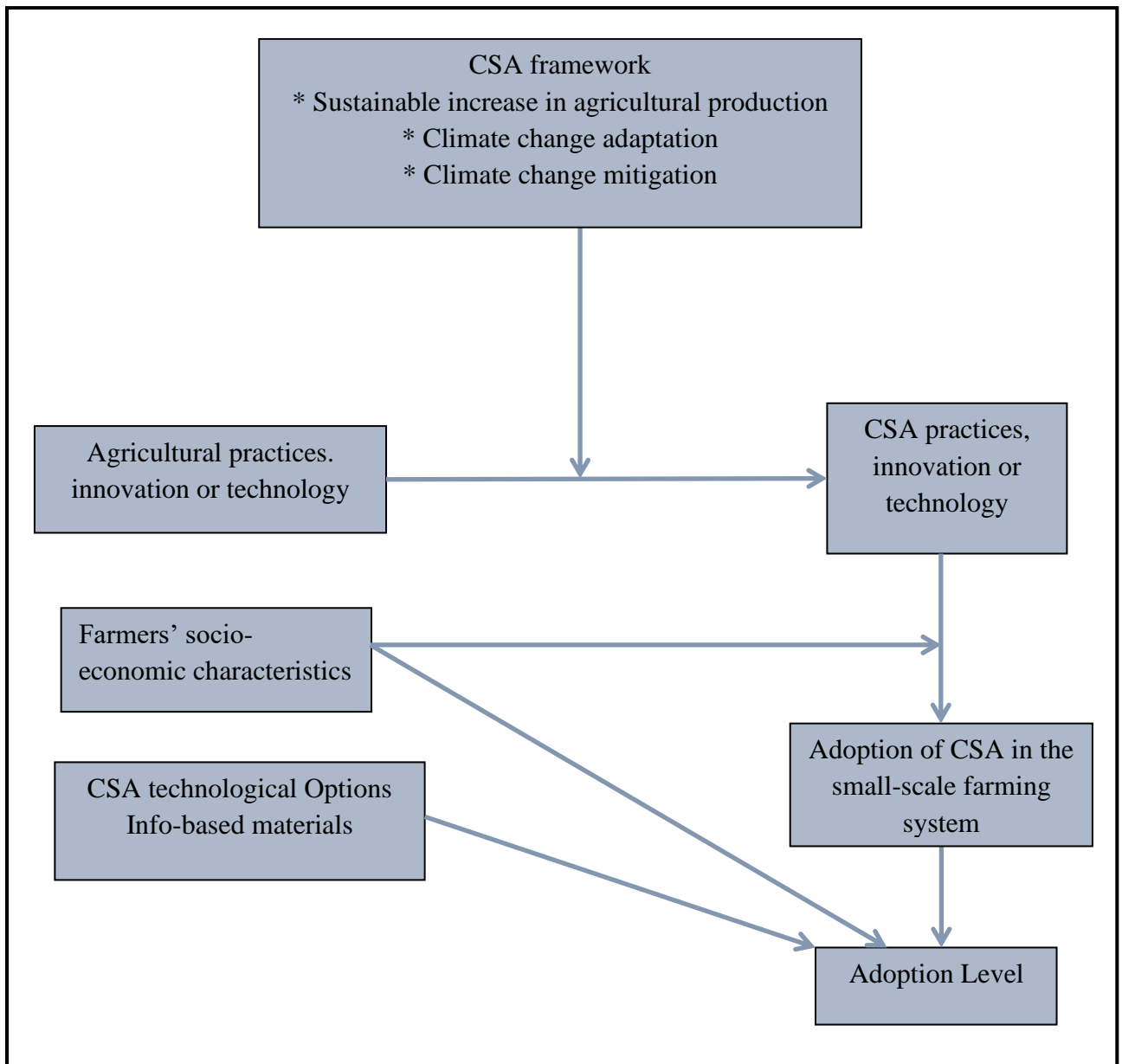


Figure 4. 1: Conceptual framework – Adoption of CSA practices among small-scale farmers  
Source: Author’s conceptualization (2019)

#### 4.2.3 Sampling Technique and Data Collection

The results presented here emanate from a sample size of 327 small-scale farming households (that is 218 and 109 in uMhlathuze and Mthonjaneni Local Municipalities respectively). Data were collected through the administration of structured questionnaires to elicit information detailed enough for descriptive and inferential analysis that would reveal the objective of the study. Focus group discussion was adopted where necessary and applicable to get more insight into the data collected. Data were collected on CSA practices and the frequency of use among

farmers. Refer to chapter three (section 3.8.1\*) for the detailed information on the sample size calculation and data collection method for this study.

#### 4.2.4 Data Analysis

The ASUI was used to analyze the degree or the extent to which the farm households use CSA in coping with the effect of climate change. This index is adapted from Adesoji and Famuyiwa (2010), Umunna *et al.* (2013) and Mohammed *et al.* (2014). Farmers were asked to assess different CSA practices by using a four-point rating scale 3, 2, 1 and 0 to denote frequently used, occasionally used, rarely used and not used respectively.

The relative level of use of the practices was calculated based on the following index formula

$$ASUI = AS_n \times 0 + AS_r \times 1 + AS_o \times 2 + AS_f \times 3 \quad (10)$$

where:

*ASUI = Adaptation Strategy Use Index*

*AS<sub>n</sub> = Frequency of farming households who did not use the climate – smart agricultural practice under consideration*

*AS<sub>r</sub> = Frequency of farming households who rarely used the climate – smart agricultural practice under consideration*

*AS<sub>o</sub> = Frequency of farming households who occasionally used the climate – smart agricultural practice under consideration*

*AS<sub>f</sub> = Frequency of farming households who frequently used the climate – smart agricultural practice under consideration*

The CSA practices considered in this study are conservation agriculture (minimum tillage, leaving crop residue on the field), agro-forestry, use of organic manure, crop rotation, crop diversification (cereal/legume intercropping), mulching, use of wetland, planting of drought and heat tolerant crops, planting of cover crops, soil conservation techniques, integrated crop-livestock management, improved grazing, efficient manure management and diet improvement for animals. These are practices that were identified to be used by the farmers in the area during the pilot survey. The ASUI was adopted to show the relative position (ranking) of the CSA practices identified in the study area in terms of their use and the extent or degree to which such practices were being used.

## 4.3 Results

### 4.3.1 Agricultural Production Activities of Respondents

The small-scale farmers interviewed in Mthonjaneni, and uMhlathuze Local Municipalities were asked to state the nature of their agricultural production activity. Table 4.1 summarizes the distribution of the respondents based on their agricultural production activity.

Table 4. 1: Distribution of Sampled Farmers based on their Agricultural Production Activity

Agricultural Production Activity	Mthonjaneni		uMhlathuze		Combined Analysis (KCDM)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Crop Production Only	47	43.1	100	45.9	147	45.0
Livestock Production Only	17	15.6	37	17.0	54	16.5
Crop and Livestock Production	45	41.3	81	37.2	126	38.5
<b>Total</b>	<b>109</b>	<b>100.0</b>	<b>218</b>	<b>100</b>	<b>327</b>	<b>100</b>

Source: Field Survey (2018/19)

Results in Table 4.1 reveal that about 43 per cent of the sampled farmers in Mthonjaneni were crop farmers, while up to 46 per cent were crop farmers in uMhlathuze Municipality. About 16 per cent of the sampled farmers in Mthonjaneni were solely into livestock production, while 17 per cent in uMhlathuze indicated that they were livestock farmers. Results further show that up to 41 per cent of the sampled farmers in Mthonjaneni were engaged in both crop and livestock production, thereby practising a mixed farming system, while only 37 per cent of their counterparts in uMhlathuze practiced mixed farming. A combined analysis of the distribution of the sampled farmers based on their agricultural production activity reveals that 45 per cent of the farmers were into sole crop production, about 17 per cent were into livestock production, while 39 per cent of the sampled farmers integrated crop and livestock production.

### 4.3.2 Level of Adoption of Climate-Smart Agricultural Practices by Crop Farmers

Table 4.2 reveals the results obtained on the frequency of adoption of CSA practices among crop farmers in Mthonjaneni and uMhlathuze Local Municipalities. The ranking of the level of use of the CSA practices based on the ASUI presented the rotational planting of crops as the

most frequently used CSA practice in Mthonjaneni (ASUI = 106), while the use of organic manure was the most frequently used practice in uMhlathuze (ASUI = 213). Results further show that the use of wetland was the least used practice with an ASUI of 22 and 73 in Mthonjaneni and uMhlathuze Municipalities, respectively. However, the soil conservation technique ranked least alongside the use of wetland in Mthonjaneni Municipality (ASUI = 22).

Results reveal that the use of organic manure and crop rotation were highly adopted by the farmers in Mthonjaneni and uMhlathuze Municipalities. The ASUI for the use of organic manure in Mthonjaneni was 100, while that of uMhlathuze was 213. The use of organic manure, based on ASUI, ranked as first among the considered practices in uMhlathuze, while it ranked as second after crop rotation in Mthonjaneni. Crop rotation had an ASUI of 106 and 183 in Mthonjaneni and uMhlathuze Municipalities, respectively. Crop rotation, based on ASUI, ranked as first among the adopted practices in Mthonjaneni, while it came after the use of organic manure in uMhlathuze, making it the second-highest in terms of ASUI ranking. About 40 per cent of the sampled farmers in Mthonjaneni claimed a frequent use of crop rotation, while 35 per cent of those in uMhlathuze claimed a frequent adoption. About 47 per cent of the farmers in Mthonjaneni indicated a frequent use of organic manure, while 42 per cent of their counterparts in uMhlathuze made use of organic manure frequently.

Table 4. 2: Ranked Order of Climate-Smart Agricultural Practices Adopted by Sampled Small-Scale Crop Farmers

Climate- Smart Agricultural Practice	Frequency of Use among Small-scale Crop Farmers																	
	Mthonjaneni						uMhlathuze						Combined Analysis (KCDM)					
	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank
Crop Rotation	19 (40.4)	21 (44.7)	7 (14.9)	0 (0.0)	106	1	35 (35.0)	34 (34.0)	10 (10.0)	21 (21.0)	183	2	54 (36.7)	55 (37.4)	17 (11.5)	21 (14.3)	289	2
Use of Organic Manure	22 (46.8)	16 (34.0)	2 (4.3)	7 (14.9)	100	2	42 (42.0)	39 (39.0)	9 (9.0)	10 (10.0)	213	1	64 (43.5)	55 (37.4)	11 (7.5)	17 (11.6)	313	1
Planting of Drought and Heat Tolerant Crops	12 (25.5)	21 (44.7)	1 (2.1)	13 (27.7)	79	3	26 (26.0)	37 (37.0)	18 (18.0)	19 (19.0)	170	3	38 (25.9)	58 (39.5)	19 (12.9)	32 (21.8)	249	3
Crop Diversification	15 (31.9)	10 (21.3)	3 (6.4)	19 (40.4)	68	4	31 (31.0)	29 (29.0)	15 (15.0)	25 (25.0)	166	4	46 (31.3)	39 (26.5)	18 (12.3)	44 (29.9)	234	4
Planting of Cover Crops	14 (29.8)	3 (6.4)	5 (10.6)	25 (53.2)	53	5	27 (27.0)	21 (21.0)	16 (16.0)	36 (36.0)	139	5	41 (27.9)	24 (16.3)	21 (14.3)	61 (41.5)	192	5
Mulching	12 (25.5)	5 (10.6)	3 (6.4)	27 (57.4)	49	6	17 (17.0)	31 (31.0)	11 (11.0)	41 (41.0)	124	6	29 (19.7)	36 (24.5)	14 (9.5)	68 (46.3)	173	6
Conservation Agriculture	4 (8.5)	10 (21.3)	6 (12.8)	27 (57.4)	38	7	17 (17.0)	27 (27.0)	14 (14.0)	42 (42.0)	119	7	21 (14.3)	37 (25.2)	20 (13.6)	69 (46.9)	157	7
Agroforestry	8 (17.0)	3 (6.4)	5 (10.6)	31 (66.0)	35	8	11 (11.0)	11 (11.0)	14 (14.0)	55 (55.0)	96	9	28 (19.1)	14 (9.5)	19 (12.9)	86 (58.5)	131	8
Use of Wetland	2 (4.3)	6 (12.8)	4 (8.5)	35 (74.5)	22	9	13 (13.0)	13 (13.0)	20 (20.0)	58 (58.0)	73	10	11 (7.5)	19 (12.9)	24 (16.3)	93 (63.3)	95	10
Soil Conservation	3 (6.4)	3 (6.4)	7 (14.9)	34 (72.3)	22	9	17 (17.0)	17 (17.0)	24 (24.0)	46 (46.0)	97	8	16 (10.9)	20 (13.6)	31 (21.1)	80 (54.4)	119	9

FU; OU; RU; NU & ASUI denote Frequently; Occasionally; Rarely; Never used & Adaptation Strategy Use Index

Source: Field Survey (2018/19)

The planting of drought and heat tolerant crops was also highly patronized by the crop farmers in both municipalities. The use of drought and heat tolerant crops, based on ASUI, ranked 3rd among the adopted CSA practices with an ASUI of 79 and 170 in Mthonjaneni and uMhlathuze Municipalities, respectively. About 26 per cent of the sampled crop farmers in each of the two municipalities indicated a frequent planting of drought and heat tolerant crops. Quite a number of the sampled farmers adopted crop diversification technique. Crop diversification had an ASUI of 68 and 166 in Mthonjaneni and uMhlathuze Municipalities, respectively. Crop diversification ranked 4th among the considered CSA practices in both municipalities. About 32 and 21 per cent of the farmers in Mthonjaneni claimed a frequent and occasional adoption of crop diversification, while 31 and 29 per cent of those in uMhlathuze claimed a frequent and occasional adoption, respectively.

Practices such as planting of cover crops ranked 5th with an ASUI of 53 and 139 in Mthonjaneni and uMhlathuze Municipalities, respectively. About 26 per cent of the crop farmers in Mthonjaneni indicated a frequent planting of cover crops, while their counterparts in uMhlathuze who also showed a frequent planting of cover crops were just a per cent more than them (27%). Mulching did not get the level of adoption that the cultivation of cover crops got in both municipalities. Mulching had an ASUI of 49 and 124 in Mthonjaneni and uMhlathuze Municipalities, respectively, ranking it as 6th among other CSA practices in both municipalities. About 26 per cent of the farmers in Mthonjaneni frequently adopted mulching, while only 17 per cent in uMhlathuze engaged in frequent use of mulching.

Conservation agriculture had an ASUI of 38 and 119 in Mthonjaneni and uMhlathuze, respectively. Conservation agriculture was ranked 7th among other considered CSA practices in both municipalities based on its ASUI. More than half (57%) of the farmers in Mthonjaneni did not adopt conservation agriculture as an adaptation strategy, while about 42 per cent of those in uMhlathuze did not adopt it at all. Agroforestry had an ASUI of 35 and 96 in Mthonjaneni and uMhlathuze respectively, ranking it as 8th in Mthonjaneni and 9th in uMhlathuze among other practices in both municipalities. The proportion of those that indicated a frequent adoption of agroforestry in uMhlathuze was 20 per cent, while it was just 8 per cent in Mthonjaneni.

The use of wetland, based on ASUI among the crop farmers, was ranked as the least used among other CSA practices as follows; in Mthonjaneni (ASUI = 22) and uMhlathuze (ASUI = 73). The majority of the farmers in both Mthonjaneni (75%) and uMhlathuze (58%) indicated

not to engage in the use of wetland at all. The adoption of soil conservation technique had an ASUI of 22 and 97 in Mthonjaneni and uMhlathuze, respectively. The ASUI ranked soil conservation technique as least used in Mthonjaneni alongside the use of wetland (9th), however as of 8th in uMhlathuze. The majority (72%) in Mthonjaneni did not adopt soil conservation at all, while the proportion of those in this category was only 46 per cent.

Results from the combined analysis of both municipalities (Mthonjaneni and uMhlathuze) did not show any considerable difference from the comparative analysis in terms of the ranking of the CSA practices based on the ASUI generated from their level of use by the farmers. The combined analysis from both municipalities reveal the use of organic manure as the most accepted practice, with an ASUI of 313. The rotational planting of crops was ranked next to the use of organic manure based on its ASUI which was 289. Results show that about 44 per cent of the farmers indicated frequent use of organic manure while 37 per cent stated a frequent use (adoption) of crop rotation technique.

Results from the combined analysis further show that the use of wetland was the least adopted with an ASUI of 95, with soil conservation ranked next to it with an ASUI of 119. About 63 per cent of the farmers responded not to engage in the use of wetland at all, while more than half (55%) of the farmers stated they did not adopt soil conservation. The other practices retained their order as obtained in the comparative analysis between the two municipalities. There was no difference in the ranking of use of these practices in the two municipalities.

#### **4.3.3 Level of Adoption of Climate-Smart Agricultural Practices by Livestock Farmers**

Table 4.3 shows the level of use of CSA practices considered among livestock farmers in Mthonjaneni and uMhlathuze. Results show that improved grazing, based on ASUI, was the most patronized CSA practice with an ASUI of 42 and 76 in Mthonjaneni and uMhlathuze Municipalities, respectively. More than half (53%) of the livestock farmers in Mthonjaneni claimed a frequent use of improved grazing, while about 38 per cent responded positively to a frequent use of improved grazing in uMhlathuze.

Efficient manure management was ranked next to improved grazing based on its ASUI, which was 40 and 64 in Mthonjaneni and uMhlathuze Municipalities, respectively. The highest proportion (42%) of the interviewed livestock farmers in Mthonjaneni indicated frequent efficient management of manure, while about 27 per cent of the farmers in uMhlathuze were in this category. Diet improvement for animals was the least patronized among the considered

practices in both municipalities. It has an ASUI of 21 and 54 in Mthonjaneni and uMhlathuze Municipalities, respectively. None of the livestock farmers in both municipalities affirmed a frequent improvement of the diet of their animals. About 47 per cent in Mthonjaneni indicated they occasionally improved the diet of their animals, while the proportion of those in uMhlathuze who reported the same response was 46 per cent.

Results from the combined analysis show the same ranking for the level of use of the CSA practices since there was no difference in the ranking of the practices with use in the two municipalities. Improved grazing was the most adopted with an ASUI of 116, followed by efficient manure management with an ASUI of 106 and then diet improvement of animals, which had an ASUI of 75. About 43 per cent of the farmers frequently adopted the practice of improved grazing, while up to 41 per cent affirmed an occasional adoption. Furthermore, about 33 per cent of the farmers indicated they frequently engaged in efficient management of manure, while up to 37 per cent stated occasional efficient management of manure. None of the farmers reported positive to diet improvement for animals, while about 46 per cent affirmed an occasional adoption of the practice. Table 4.3 summarizes the ranked order of CSA practices adopted by the sampled livestock farmers.

Table 4. 3: Ranked Order of Climate-Smart Agricultural Practices Adopted by the Sampled Livestock Farmers

Climate- Smart Agricultural Practice	Frequency of Use among Small-scale Crop Farmers																	
	Mthonjaneni						uMhlathuze						Combined Analysis (KCDM)					
	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank
Improved Grazing	9 (52.9)	7 (41.2)	1 (5.9)	0 (0.0)	42	1	14 (37.8)	15 (40.5)	2 (5.4)	6 (16.2)	76	1	23 (42.6)	22 (40.7)	3 (5.6)	6 (11.1)	116	1
Efficient Manure Management	8 (47.1)	7 (41.2)	2 (11.8)	0 (0.0)	40	2	10 (27.0)	13 (35.1)	8 (26.1)	6 (16.2)	64	2	18 (33.3)	20 (37.0)	10 (18.5)	6 (11.1)	104	2
Diet Improvement for Animals	0 (0.0)	8 (47.1)	5 (29.4)	4 (23.5)	21	3	0 (0.0)	17 (45.9)	20 (54.1)	0 (0.0)	54	3	0 (0.0)	25 (46.3)	25 (46.3)	4 (7.4)	75	3

FU; OU; RU; NU & ASUI denote Frequently; Occasionally; Rarely; Never used & Adaptation Strategy Use Index  
Source: Field Survey (2018/19)

#### **4.3.4 Level of Adoption of Climate-Smart Agricultural Practices adopted by Farmers Engaged in both Crop and Livestock Production**

Table 4.4 presents results on the level of use of the CSA practices adopted by the sampled farmers engaged in mixed farming in both Mthonjaneni and uMhlathuze Municipalities. Results show that integrated crop-livestock management, diet improvement for animals and the use of organic manure were highly adopted practices among the sampled farmers in both municipalities. Integrated crop-livestock management was the most (ASUI = 120) approved practice in Mthonjaneni, while diet improvement for animals was the most (ASUI = 191) adopted in uMhlathuze. The use of organic manure was the second highest in terms of level of adoption among the sampled farmers with an ASUI of 109 and 183 in Mthonjaneni and uMhlathuze, respectively.

Results show that integrated crop-livestock management had an ASUI of 120 in Mthonjaneni, ranking it as the most adopted practice among the sampled farmers engaged in mixed farming in the municipality. However, it was ranked third among other practices based on its level of use among farmers in uMhlathuze, having an ASUI of 162. About 69 per cent of the sampled farmers engaged in mixed farming in Mthonjaneni affirmed a frequent use of the practice, while 47 per cent of those in uMhlathuze responded positively to a frequent use of the practice. About 29 per cent in Mthonjaneni claimed an occasional use, while 28 per cent of those in uMhlathuze claimed an occasional use.

The use of organic manure was ranked second highest based on the level of use with an ASUI of 109 and 183 in Mthonjaneni and uMhlathuze Municipalities, respectively. About 51 per cent of the sampled farmers in Mthonjaneni indicated frequent use of organic manure, while their counterparts in uMhlathuze claimed about 54 per cent. About 44 per cent in Mthonjaneni stated an occasional use, while only 27 per cent attested to occasional use in uMhlathuze.

The adoption of crop rotation had an ASUI of 107 and 161 in Mthonjaneni and uMhlathuze Municipalities, respectively. Among other practices considered, based on its level of use, it was ranked 3rd in Mthonjaneni and 4th in uMhlathuze. About 49 per cent of the sampled farmers in Mthonjaneni stated a frequent adoption of crop rotation, while only 37 per cent agreed to a frequent use of crop rotation. About 40 and 41 per cent claimed an occasional use in Mthonjaneni and uMhlathuze, respectively.

Table 4. 4: Ranked Order of Climate-Smart Agricultural Practices Adopted by Sampled Small-Scale Farmers Engaged in both Crop and Livestock Production

Climate- Smart Agricultural Practice	Frequency of Use among Small-scale Crop Farmers																	
	Mthonjaneni						uMhlathuze						Combined Analysis (KCDM)					
	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank	FU No. (%)	OU No. (%)	RU No. (%)	NU No. (%)	ASUI	Rank
Integrated Crop-Livestock Management	31 (68.9)	13 (28.9)	1 (2.2)	0 (0.0)	120	1	38 (46.9)	23 (28.4)	2 (2.5)	18 (22.2)	162	3	69 (54.8)	36 (28.6)	3 (2.4)	18 (14.3)	282	2
Use of Organic Manure	23 (51.1)	20 (44.4)	0 (0.0)	2 (4.4)	109	2	44 (54.3)	22 (27.2)	7 (8.6)	8 (9.9)	183	2	67 (53.2)	42 (33.3)	7 (5.6)	10 (7.9)	292	1
Crop Rotation	22 (48.9)	18 (40.0)	5 (11.1)	0 (0.0)	107	3	30 (37.0)	33 (40.7)	5 (6.2)	13 (16.0)	161	4	52 (41.3)	51 (40.5)	10 (7.9)	13 (10.3)	268	3
Planting of Drought and Heat Tolerant Crops	19 (42.2)	19 (42.2)	2 (4.4)	5 (11.1)	97	4	27 (33.3)	30 (37.0)	13 (16.0)	11 (13.6)	154	5	46 (36.5)	49 (38.9)	15 (11.9)	16 (12.7)	251	4
Improved Grazing	16 (35.6)	20 (44.4)	9 (20.0)	0 (0.0)	97	4	18 (2.2)	42 (51.9)	8 (9.9)	13 (16.0)	146	6	34 (27.0)	62 (49.2)	17 (13.5)	13 (10.3)	243	5
Crop Diversification	19 (42.2)	15 (33.3)	2 (4.4)	9 (20.0)	89	6	28 (34.6)	21 (25.9)	13 (16.0)	19 (23.5)	139	7	47 (37.3)	36 (28.6)	15 (11.9)	28 (22.2)	228	6
Conservation Agriculture	19 (42.2)	12 (26.7)	3 (6.7)	11 (24.4)	84	7	15 (18.5)	18 (22.2)	12 (14.8)	36 (44.4)	93	11	34 (27.0)	30 (23.8)	15 (11.9)	47 (37.3)	177	11
Efficient Manure Management	6 (13.3)	23 (51.1)	15 (33.3)	1 (2.2)	79	8	4 (4.9)	39 (48.1)	24 (29.6)	14 (17.3)	114	10	10 (7.9)	62 (49.2)	39 (31.0)	15 (11.9)	193	8
Planting of Cover Crops	14 (31.1)	11 (24.4)	6 (13.3)	14 (31.1)	70	9	26 (32.1)	16 (19.8)	11 (13.6)	28 (34.6)	121	9	40 (31.8)	27 (21.4)	17 (13.5)	42 (33.3)	191	9
Mulching	10 (22.2)	10 (22.2)	4 (8.9)	21 (46.7)	54	10	27 (33.3)	24 (29.6)	6 (7.4)	24 (29.6)	135	6	37 (29.4)	34 (27.0)	10 (7.9)	45 (35.7)	189	10
Use of Wetland	7 (15.6)	6 (13.3)	8 (17.8)	24 (53.3)	41	11	13 (16.0)	8 (9.9)	15 (18.0)	45 (55.6)	70	13	20 (15.9)	14 (11.1)	23 (18.3)	69 (54.8)	111	13
Soil Conservation	9 (20.0)	1 (2.2)	12 (26.7)	23 (51.1)	41	11	14 (17.3)	13 (16.0)	12 (14.8)	42 (51.9)	80	12	23 (18.3)	14 (11.1)	24 (19.1)	65 (51.6)	121	12
Diet Improvement for Animals	1 (2.2)	3 (6.7)	14 (31.1)	27 (60.0)	23	13	31 (38.3)	48 (59.3)	2 (0.9)	0 (0.0)	191	1	32 (25.4)	51 (40.5)	16 (12.7)	27 (21.4)	214	7
Agroforestry	1 (2.2)	6 (13.3)	1 (2.2)	37 (82.2)	16	14	6 (7.4)	6 (7.4)	9 (11.1)	60 (74.1)	39	14	7 (5.6)	12 (9.5)	10 (7.9)	97 (77.0)	55	14

FU; OU; RU; NU & ASUI denote Frequently; Occasionally; Rarely; Never used & Adaptation Strategy Use Index  
Source: Field Survey (2018/19)

The planting of drought and heat tolerant crops had an ASUI of 97 and 154 in Mthonjaneni and uMhlathuze Municipalities, respectively. Planting of drought and heat tolerant crops was ranked 4th in Mthonjaneni and 5th in uMhlathuze among other practices based on its level of use. About 42 per cent of the sampled farmers in Mthonjaneni were into frequent planting of drought and heat tolerant crops, while 33 per cent frequently planted drought and heat tolerant crops. Another 42 per cent in Mthonjaneni stated an occasion planting of drought and heat resistant crops, while 27 per cent adopted the practice occasionally in uMhlathuze.

The use of wetland was not entirely adopted in both municipalities. It had an ASUI of 41 and 70 in Mthonjaneni and uMhlathuze Municipalities, respectively. Only 16 per cent of the farmers in each of the two municipalities indicated a frequent use. About 13 per cent in Mthonjaneni stated an occasional use, while just 9 per cent of those in uMhlathuze made the same claim. Soil conservation was not a well patronized CSA practice in both municipalities when compared with other practices. It had an ASUI of 41 and 80 in Mthonjaneni and uMhlathuze, respectively. About 20 per cent of the sampled farmers in Mthonjaneni indicated a frequent adoption of soil conservation, while 17 per cent of those in uMhlathuze made the same claim. Only 2 per cent of those in Mthonjaneni stated an occasional use, while 16 per cent of those in uMhlathuze made the same claim.

Diet improvement for animals was not a well patronized CSA practice by farmers engaged in mixed farming in Mthonjaneni, while it was the most adopted in uMhlathuze. It had an ASUI of 23, ranking it as 13 in Mthonjaneni, but had an ASUI of 191, ranking it as the most adopted in uMhlathuze. Only 2 per cent of the sampled farmers in Mthonjaneni indicated a frequent adoption, while up to 38 per cent affirmed a frequent adoption of diet improvement for their animals. Only 7 per cent of those in Mthonjaneni agreed to an occasional adoption, while up to 60 per cent of those in uMhlathuze stated they occasionally improved the diet of their animals. Agroforestry was the least adopted by the farmers in both municipalities. It had an ASUI of 16 and 39 in Mthonjaneni and uMhlathuze Municipalities, respectively. Only 2 per cent of the farmers responded favorable to a frequent adoption of agroforestry, while about 7 per cent of those in uMhlathuze made the same claim.

Other practice such as improved grazing was also ranked as 4th alongside with planting of drought and heat tolerant crops in Mthonjaneni, while it was ranked 6th in uMhlathuze based on the ASUI, reflecting the level of use. About 36 per cent of the sampled farmers in

Mthonjaneni frequently adopted improved grazing for their animals, while only 2 per cent in uMhlathuze responded positively to improved grazing. Crop diversification had an ASUI of 84 among the sampled farmers in Mthonjaneni and 93 in uMhlathuze, ranking it as 7th and 11th in Mthonjaneni and uMhlathuze, respectively. About 42 per cent in Mthonjaneni diversified their crop production, while only 35 per cent in uMhlathuze were into crop diversification.

Conservation agriculture had an ASUI of 84 and 93 in Mthonjaneni and uMhlathuze Municipalities, respectively. From the ASUI, which reflects the level of use in both municipalities, it ranked 7th in Mthonjaneni and 11th in uMhlathuze. Up to 42 per cent of the sampled farmers in Mthonjaneni claimed a frequent use of conservation agriculture, while only 19 per cent in uMhlathuze claimed a frequent use. Efficient manure management was ranked 8th among other practices in Mthonjaneni and 10th in uMhlathuze. It had an ASUI of 79 and 114 in Mthonjaneni and uMhlathuze, respectively. About 13 per cent in Mthonjaneni stated frequent efficient management of manure as CSA practice, while only 5 per cent in uMhlathuze respond to a frequent adoption of the practice.

The planting of cover crops was ranked 9th among other practices in both municipalities. It had an ASUI of 70 and 121 in Mthonjaneni and uMhlathuze, respectively. About 31 per cent in Mthonjaneni indicated they frequently planted cover crops, while 32 per cent of those in uMhlathuze made the same claim. Mulching had an ASUI of 54 and 135 in Mthonjaneni and uMhlathuze, respectively. Mulching was ranked 10th based on the level of use in Mthonjaneni and 6th in uMhlathuze. About 22 per cent of the sampled farmers in Mthonjaneni indicated a frequent adoption of mulching, while 33 per cent of those in uMhlathuze made the same claim.

Results from the combined analysis reveal that the use of organic manure was the most adopted CSA practice by the sampled farmers engaged in mixed farming with an ASUI of 292. More than half (53%) of the sampled farmers indicated frequent use of organic manure, while 33 per cent stated an occasional use. Next to the use of organic manure in terms of the level of use among the sampled farmers was integrated crop-livestock management, with an ASUI of 282. More than half (55%) of the sampled farmers indicated a frequent adoption of the practice, while 29 per cent affirmed an occasional use.

Results also show that crop rotation was also a well patronized CSA practice, with an ASUI of 268. About 41 per cent of the sampled farmers frequently engaged in crop rotation, while 41 per cent engaged in it occasionally. The planting of drought and heat tolerant crops had an

ASUI of 251, ranking it as 4th among other practices. About 37 per cent of the sampled farmers stated a frequent adoption of planting drought and heat tolerant crops, while up to 39 per cent claimed an occasional adoption.

Improved grazing had an ASUI of 243, ranking it as 5th on the level of adoption when compared with other practices. About 27 per cent indicated a frequent adoption of improved grazing, while up to 49 per cent stated an occasional adoption. Crop diversification was next to improved grazing in terms of the level of use as it had an ASUI of 228. About 37 per cent of the sampled farmers stated a frequent diversification of their crop cultivation, while 29 per cent indicated they occasionally diversify their crop cultivation.

Results from the combined analysis reveal that conservation agriculture was not a well patronized CSA practice. It had an ASUI of 177, ranking it as 11th. About 27 per cent of the sampled farmers indicated a frequent adoption of conservation agriculture, while 24 per cent of the farmers stated an occasional adoption. Efficient management of manure had an ASUI of 193, ranking it as 8th among other practices. Only 8 per cent of the sampled farmers claimed a frequent adoption of efficient manure management, while up to 49 per cent claimed an occasional adoption.

Planting of cover crops had an ASUI of 191, ranking it next to the efficient management of manure on the level of use. About 32 per cent of the sampled farmers indicated they frequently planted cover crops, while 21 per cent stated an occasional planting. Mulching had an ASUI of 189 ranking it next to the cultivation of cover crops based on level of use. About 29 per cent of the sampled farmers stated a frequent use of mulching, while about 27 per cent reported an occasional use.

The adoption of soil conservation was not well patronized as it had an ASUI of 121, ranking it as 12th among other practices based on level of use. More than half (52%) of the sampled farmers indicated they did not adopt soil conservation technique. Next in ranking to soil conservation technique was the use of wetland with an ASUI of 111. More than half (55%) of the sampled farmers indicated they did not adopt the use of wetland.

Diet improvement for animals had an ASUI of 214, ranking it as 7th on a combined level of analysis. About 25 per cent of the sampled farmers indicated a frequent improvement of diet for their animals, while about 41 per cent stated they occasionally improved the diet of their animals. Results from the combined analysis show that agroforestry was the least adopted

among the sampled farmers, with an ASUI of 55. The majority (77%) of the sampled farmers stated they did not adopt agroforestry.

#### **4.4 Discussion**

The analysis of the agricultural production activities of farmers in the study area shows that small-scale farmers in the area were either into crop cultivation, livestock production or engaged in mixed farming, which is the integration of both crop and livestock production. The highest proportion of the farmers in the two municipalities were into cultivation of crops, while the least proportion was engaged with livestock production. A similar pattern of agricultural activities could be inferred from the results obtained for both municipalities. The finding is in contrast with the conclusion made by Tibesigwa and Visser (2015) in their study on subsistence farming in South Africa that there were more farmers who were engaged with livestock production when compared with those involved with crop production or those engaged with the integration of the two farming systems.

The sampled crop farmers in both Mthonjaneni and uMhlathuze Municipalities have different CSA practices they adopted as adaptive strategies to cope with climate change. Analysis of the responses gathered from the farmers in both municipalities presented crop rotation, the use of organic manure and the planting of drought and heat tolerant crops as the three most patronized CSA practices. The difference in the pattern observed comes only in the order of ranking of these three practices based on their ASUI which ranked crop rotation as the most adopted CSA practice in Mthonjaneni Municipality and the use of organic manure in uMhlathuze. Studies have reported similar findings on adaptation practices whereby rotational cropping, the use of organic manure and planting of drought and heat tolerant crops were highly noted adaptive strategies among small-scale crop farmers (Onyeneke, 2010; Mburu *et al.*, 2015; Onyeneke *et al.*, 2018). Mitigation and adaptation to drought conditions have been reported to be carried out by rural communities in Ghana through rotational planting of crops (Utama & Balia, 2018).

The three least engaged practices among the considered CSA practices by the sampled crop farmers were agroforestry, the use of wetland and soil conservation. Interestingly, this section of the result shows a similar pattern for both municipalities as well. From the analysis of the responses gathered from the crop farmers in both municipalities, it could be inferred that agroforestry and soil conservation techniques were not CSA practices the majority of the samples farmers would adapt easily and on frequent occasions and this could be attributed to the fact these farmers were on small-scale production.

Responses from livestock farmers reveal a similar approach to climate change adaptation in both municipalities. Results show that the livestock farmers in both municipalities were quick to improve their grazing system as an adaptation strategy. There were those that adopted the option of enhancing the diet of their animals, while some opted for efficient manure management. However, the ASUI analysis reveals that improved grazing was the most patronized CSA practice among the livestock farmers, in both municipalities. The reason for this pattern could be the technicalities and cost associated with diet improvement for animals and efficient manure management. A relatively minor technicality is associated with improved grazing, and small-scale farmers would find it easier to relate. This finding is in contrast with that of Adesoji and Famuyiwa (2010) who reported a reduction of herd numbers, digging of well and excavation of marshy land as strategies adopted by livestock farmers in coping with climate change.

Farmers who were into mixed farming in Mthonjaneni Municipality embraced the integration of crop and livestock management as their primary adaptation strategy. The use of organic manure and crop rotation were also well adopted, but the ASUI presented integrated crop-livestock management as the most patronized CSA practice among the farmers. This strategy is already in line with the nature of their agricultural activity. On the other hand, the farmers resident in uMhlathuze Municipality who were in this category focused more on improving the diet of their animals. This suggests the sampled farmers in uMhlathuze could be more skilled in this area or they enjoy more advisory services than their counterparts in Mthonjaneni. Besides, the results indicate that the sampled farmers in uMhlathuze gave more attention to their animals while making an effort to cope with climate variability, despite integrating crop and livestock production. Studies such as Uddin *et al.* (2014), Mburu *et al.* (2015), Kitsao (2016) and Tibesigwa *et al.* (2017) also establish integrated crop-livestock management as a CSA practice adopted by small-scale farmers.

The pattern and level of adoption of the considered CSA practices among the farmers engaged with both crop and livestock production are similar for both municipalities. Agroforestry and soil conservation are among the category of the least adopted, just like they were among the crop farmers. However, the twist in the pattern is on diet improvement for animals among the farmers in Mthonjaneni. The farmers in the municipality showed a deficient level of adoption for this practice when compared with other practices, unlike their counterparts in uMhlathuze who embraced it as the most patronized CSA practice.

## **4.5 Conclusion and policy implications**

There is a substantial gap in the evidence base as regards addressing technical issues associated with the downscaling of models that are more applicable for policy designs and implementation meant for tackling climate change problems at the local level. This brings about the need for the assessment of the dispositions of small-scale farmers to the adaptation and mitigation potentials of different agricultural practices. This paper fills this gap by evaluating the extent of the adoption of CSA practices by small-scale farming households in the study area/ s. Findings show that rotational cropping, use of organic manure and planting of drought and heat tolerant crops were popular CSA practices for crop production, while improved grazing, efficient manure management and diet improvement for animals were the standard CSA practices among the livestock farmers. The findings from this paper reveal that small-scale farmers are already making efforts to adjust to and cope with climate change. Several practices adopted by the farmers fit into CSA profile as explained by FAO.

This paper argues that understanding the pattern of adoption among farmers is essential for a successful mainstreaming of climate-smart agricultural related projects and empowering farmers, mainly the small-scale in achieving sustainable agriculture under climate change. Therefore, it is recommended that policymakers and other agricultural stakeholders should involve small-scale farmers in designing agricultural development programs and projects focusing on surviving climate change challenges. This will make implementation much easier amidst farmers. There may not be a holistic clarity on what motivates their choice of practice, as this paper did not examine that. However, future studies can be extended into shedding light on that. This paper also encourages researchers to extend the scope of this study in further research on indigenous practices among local farmers that can fit into CSA profile. This study can be further expanded, for example, by extending it to other areas in South Africa to enhance the reliability of the findings.

### **Author Contributions**

V.O.A. conceived and designed the study. V.O.A collected and analyzed the data for the study and drafted the manuscript. M.S. and A.O. supervised the study. M.S and A.O scrutinized and verified the research process, methods and the manuscript. All authors contributed to the outcome of the manuscript.

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**Conflict of interest**

The authors declare no conflict of interest.

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**CHAPTER FIVE<sup>2</sup>**  
**DETERMINANTS OF THE ADOPTION OF CLIMATE-SMART AGRICULTURE**  
**PRACTICES BY SMALL-SCALE FARMING HOUSEHOLDS IN KING**  
**CETSHWAYO DISTRICT MUNICIPALITY**

**Abstract**

Agriculture in general, and small-scale farming in particular is both a contributor to GHG emissions and a victim of the effects of climate change. Climate-smart agriculture offers a unique opportunity to farmers to adapt to the effects of climate change while at the same time mitigating GHG emissions. Yet, there has been a problematically low response to adopting CSA among small-scale farmers. This paper investigates the factors affecting CSA adoption by small-scale farming households in KCDM. A multi-stage sampling technique was used for sample selection. Data were generated, with the aid of a structured questionnaire from 327 small-scale farmers in KCDM, making a comparison between two local municipalities (Mthonjaneni and uMhlathuze) selected from the district based on their agricultural potentials. Descriptive statistics, Composite Score and a Generalized Ordered Logit Regression (gologit) model were used to analyze data, revealing that 57% of the sampled farmers are in the medium user category of CSA practices and 18% in the high user category. Marital status, educational status, farm income, farming experience, agricultural production activity, contact with agricultural extension, membership to an agricultural association or group; exposure to media and the perception on the impact of climate change were found to be statistically significant and positively correlated with the level of CSA adoption. Furthermore, off-farm income and distance of farm to homestead were statistically significant but negatively correlated with level of CSA adoption. This paper, therefore, argues that climate change-related education through improved extension contact and exposure to mass media, strengthening integrated farm activities that bolster farm income, farmer associations or groups should be used to facilitate CSA adoption as means of climate change mitigation and resilience.

**Keywords:** Adaptation, climate change, climate-smart agriculture, small-scale farming, mitigation

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<sup>2</sup> N/B This chapter is prepared as an article for submission to an accredited journal.

\* Text that has already been explained in the methodology chapter will be skipped, with only reference given to.

## 5.1 Introduction

The climate related shocks in agricultural production that farmers have to deal with have highlighted the need for resilience to the forefront of agricultural policies across the world (Vera *et al.*, 2017). There is growing interest among policymakers and development practitioners to get as many farmers as possible, especially small-scale farmers, to embrace sustainable farming practices that will fortify agricultural and food systems. Climate change, to a great extent, has been the outcome of the accumulation of GHG, which is caused by human activities (Vermeulen, 2014). Agricultural activities such as bush burning and deforestation are part of the human activities contributing to GHG emissions (IPCC, 2014; Lamboll *et al.*, 2017). Climate change has globally influenced natural and social systems (IPCC, 2014). However, studies have shown that developing countries, particularly African countries are more susceptible to the influence of climate change (Williams *et al.*, 2015; Serdeczny *et al.*, 2017; Abegunde & Sibanda, 2018). The small-scale farming system in African countries is predominantly rain-fed, making it highly susceptible to climate change and variability (Tibesigwa *et al.*, 2015; Akrofi-Atitianti *et al.*, 2018).

Among the many approaches that have been recommended for mitigating the impacts of climate change on farming system, CSA practices that integrate the benefits of a sustainable increase in agricultural productivity, the adaptation and building of resilient agricultural and food security systems, as well as the reduction of GHG emissions from agricultural activities, have appeared to be very promising (FAO, 2013; Lipper *et al.*, 2014). Researchers are left with the responsibility of informing policymakers on factors that can influence the adoption of these practices so that they can enact well-informed and practicable strategies that will facilitate the successful adoption of these practices by farmers.

Studies have been conducted to explore CSA adoption among farmers (Murray *et al.*, 2016; Ojoko *et al.*, 2017; Akrofi-Atitianti *et al.*, 2018; Aryal *et al.*, 2018). Ojoko *et al.* (2017) reveal that education, membership of social group and access to credit are significant determinants of CSA adoption in Sokoto State in Nigeria. Akrofi-Atitianti *et al.* (2018) found that the location of farms, farmers' age, residential status and access to extension services influence CSA adoption in the cocoa farming system in Ghana. Aryal *et al.* (2018) studied the factors influencing the adoption of CSA practices by farmers in the Indo-Gangetic plains of India and noted that farmers' characteristics such as gender, education, social and economic capital, as well as farmers' experience of climate risks and access to extension services and training were

critical determinants. Murray *et al.* (2016) have also argued for greater attention to gender issues in the development and adoption of CSA tools and technologies.

The majority of these studies focus on a single CSA practice or strategy. The concept of CSA encompasses a set of practices that farmers adapt in different combinations (Pannell *et al.*, 2014; Vera *et al.*, 2017). Furthermore, given the location and content-specific attributes of CSA application in terms of economic, environmental and social contexts, there is the need for location-specific studies on CSA. However, there is little information concerning CSA adoption in South Africa, particularly as it relates to the small-scale farming system.

According to Vera *et al.* (2017) and Teklewold *et al.* (2013), farmers enjoy more benefits when they adopt multiple strategies, as some of the strategies can be complementary to one another and enable the farmers to exploit relevant synergies. As a result, the adoption of multiple CSA practices helps in building a sustainable agricultural system that is strongly resilient to shocks which are related to climate change and other factors threatening agricultural production.

This paper aims to bridge the information gap on CSA adoption in small-scale agriculture by assessing the factors affecting the level of adoption of CSA practices by small-scale farmers using data collected from small-scale farmers in the KCDM of KwaZulu-Natal province, South Africa. Following studies by Vera *et al.* (2017), Ojoko *et al.* (2017), Teklewold *et al.* (2013) and Wekesa *et al.* (2018), the CSA practices adopted by farmers in the study area were identified, and then used to investigate the level of adoption of CSA practices among the sampled farmers. These practices include conservation agriculture (minimum tillage, leaving crop residue on the field), agro-forestry, use of organic manure, crop rotation, crop diversification (cereal/legume intercropping), mulching, use of wetland, planting of drought and heat tolerant crops, planting of cover crops, soil conservation techniques, integrated crop-livestock management, improved grazing, efficient manure management and diet improvement for animals.

## **5.2 Materials and Methods**

### **5.2.1 Study Area**

As earlier stated in chapter four of this thesis, the research study was conducted in KCDM of KZN Province of the Republic of South Africa. Refer to chapter three (section 3.2) for the detailed information on the description and selection of study area/s.

### **5.2.2 Research Design**

A cross-sectional research design was adopted. Refer to chapter three (section 3.7) for the detailed information on the description and rationale of the chosen design.

#### ***Conceptual framework***

The conceptual framework is the same as discussed in chapter four (section 4.2.2).

### **5.2.3 Sampling Technique and Data Collection**

The sampling technique and procedure for data collection is the same as already described in chapter four. Refer to chapter three (section 3.8.1\*) for detailed information on the sample size calculation and data collection procedures.

### **5.2.4 Data Analysis**

The factors influencing the level of use of CSA by the small-scale farming households in the study area/ s were analyzed using the composite score and the gologit model. The composite score was used to measure and compute the level of use of CSA practices by the small-scale farming households in the study area/ s. A binary scale that is using 1 to represent yes and 0 to represent no, with respect to the use of any of the identified CSA practices in the study area/ s were used in rating the responses of the farmers. With the 14 statements and response, a respondent can only have 14 and 0 as maximum and minimum points respectively. The respondents can then be categorized into high, medium and low users with the use of a composite score (Adepoju *et al.*, 2011; Ojoko *et al.*, 2017).

High user = those whose points fall between 14 and (Mean + S.D) points

Medium user = those between upper and lower categories

Low user = those whose points fall between (Mean – S.D) and 0

The category of the farmers from the composite score is used as a dependent variable, with hypothesized factors as independent variables in a gologit model.

#### ***The Proportional Odds Assumption for the Generalized Ordered Logit Model***

One of the underlying assumptions of the ordered logistic and ordered probit regression models is that the relationship between each pair of outcome groups is the same. Invariably, ordered

logistic and ordered probit regression models operate on the assumption that the coefficients that describe the relationship between, for example, the lowest and all higher categories of the response variable are the same as that describing the relationship existing between the next lowest and all higher categories. This assumption is called the proportional odds assumption or the parallel regression assumption. However, when the proportional odds assumption or the parallel regression assumption is violated, a generalized ordered logistic model becomes a more appropriate model (Williams, 2006; Long & Freese, 2014).

### ***Generalized Ordered Logit Regression***

A significant comparative advantage of generalized ordered logit regression model is that it can estimate two exceptional cases of the generalized model; the proportional odds model and the partial proportional odds model. Generalized ordered logit regression can estimate models with lesser restrictions than the proportional odds or parallel lines models estimated by the ordinary ordered logit regression, whose assumptions are often violated, but more parsimonious and interpretable than those estimated by non-ordinal methods such as multinomial logistic regression (Williams, 2006; Long & Freese, 2014).

The generalized ordered logit regression model is expressed as:

$$P(Y_i > j) = g(X\beta_j) = \frac{\exp(\alpha_j + X_i\beta_j)}{1 + \{\exp(\alpha_j + X_i\beta_j)\}}, j = 1, 2, \dots, M - 1 \quad (11)$$

Where  $M$  is the number of categories of the ordinal dependent variable. From the equation stated above, the probabilities that  $Y$  will take on each of the values  $1, \dots, M$  are equal to

$$P(Y_i = 1) = 1 - g(X_i\beta_j) \quad (12)$$

$$P(Y_i = j) = g(X_i\beta_{j-1}) - g(X_i\beta_j) \quad j = 2, \dots, M - 1 \quad P(Y_i = M) = g(X_i\beta_{M-1})$$

The dependent variable  $Y_i$  = level of usage of climate-smart agricultural practices (3 = High user, 2 = Medium user, 1 = Low user)

The independent variables considered include:

$X_1$  = Age of the person responsible for household farming activities (years)

$X_2$  = Educational status of the person responsible for household farming activities (years in school)

$X_3$  = Household size (number of household members)

- X<sub>4</sub> = Average monthly farm income (Measured in South African Rand (ZAR))
- X<sub>5</sub> = Average monthly off-farm income (Measured in ZAR)
- X<sub>6</sub> = Farming experience (years)
- X<sub>7</sub> = The distance of farm to homestead (km)
- X<sub>8</sub> = Contact with extension agents (number of yearly visits)
- X<sub>9</sub> = Exposure to media (number of mass media outfits accessed)
- X<sub>10</sub> = Gender of the person responsible for household farming activities (1 = male; female = 0)
- X<sub>11</sub> = Marital status of the person responsible for household farming activities (married = 1; otherwise = 0)
- X<sub>12</sub> = Production activity (mixed farming =1; one enterprise activity = 0)
- X<sub>13</sub> = Membership to an agricultural-related group (yes = 1 if member; otherwise = 0)
- X<sub>14</sub> = Perception of the effect of climate change (significant adverse impact = 1; otherwise = 0)

When  $M = 2$ , the generalized ordered logit model is an equivalence of the logistic regression model. When  $M > 2$ , the model becomes an equivalence of a series of binary logistic regressions where categories of the dependent variable are combined. For example, if  $M = 4$ , then  $J = 1$ , category 1 is contrasted with categories 2, 3 and 4. For  $J = 2$ , the contrast is between categories 1 and 2 against 3 and 4, while for  $J = 3$ , it is 1, 2 and 3 against 4.

***Description of the Explanatory Variables used in the Gologit Model***

The explanatory variables inputted in the gologit model for the analysis of the determinants of the level of CSA adoption among the sampled small-scale farmers include respondents’ age, educational status, household size, farm income, off-farm income, farming experience, distance of farm to homestead, contact with extension agents, exposure to media, gender, marital status, agricultural production activity, membership of agricultural-related group, and perception of the effect of climate change. Table 5.1 summarizes the explanatory variables entered in the gologit model and their expected outcomes.

Table 5. 1: Explanatory variables in the gologit model used for the analysis of the determinants of the level of CSA adoption and their expected outcomes

<b>Variable</b>	<b>Description and measurement type</b>	<b>Expected outcome (+/-)</b>
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Age	Age of respondent in years (continuous)	-
Educational status	Number of years spent by respondents in acquiring formal education (continuous)	+
Household size	Number of members in the household (continuous)	+
Average monthly farm income (ZAR)	Total monthly income from farm enterprise (continuous)	+
Average monthly off-farm income (ZAR)	Total monthly income from non-farm enterprise (continuous)	-
Farming experience	Number of years spent in farming (continuous)	+
The distance of farm to homestead	The distance of home to the farm location in kilometers (continuous)	-
Contact with extension agents	Number of yearly visits of extension agents (continuous)	+
Exposure to media	Number of mass media outfits accessed (continuous)	+
Gender	Respondents' gender (male = 1; female = 0) (dummy)	+/-
Marital status	Marital status of respondents (married = 1; otherwise = 0) (dummy)	+/-
Agricultural Production activity	Nature of farming activity (mixed farming = 1; one enterprise activity = 0) (dummy)	+/-
Membership to an agricultural-related group	Whether the respondent belongs to an agricultural-related group or association (yes = 1; otherwise = 0) (dummy)	+
Perception of the effect of climate change	Perception of respondent on the effect of climate change (significant adverse effect = 1; otherwise = 0) (dummy)	+

+/- Denote a positive or negative association to the dependent variable

Source: Author (2019)

Age of the respondent was captured in the gologit regression model as a continuous variable. The age of the respondents was measured in actual years since the date of birth. Age was anticipated to have a negative correlation with the level of CSA adoption. The educational status of the respondents was also inputted in the gologit model as a continuous variable, where it was captured as the number of years spent in school. Ngema *et al.* (2018) stated that an educated farmer is expected to approach farming with insights from exposure to information. Educational status is anticipated to correlate positively with level of CSA adoption. The household size in this paper represents the number of people residing in a home together at the time of the study. Household members can translate to family labor to whom important farming activities can be delegated (Ngema *et al.*, 2018). This situation could enhance agricultural production. The average monthly income realized from farming and non-farming activities by the households was measured as a continuous variable in South African Rands (ZAR). Average

monthly farm income is expected to have a positive correlation with the level of CSA adoption. By contrast, average monthly income from off-farm activities is anticipated to have a negative correlation with the level of CSA adoption, as engagement in alternative source/ s of income would likely reduce commitment to farming.

The farming experience of the respondents was captured as the number of years spent in farming. According to Onyeneke *et al.* (2018), the more experienced a farmer is, the more open he/she is to adopt techniques or new technologies that can boost his/her productivity. Farming experience is anticipated to positively correlate with the level of CSA adoption. The distance of farm to the homestead was captured as the measure of the distance of the location of residence of the respondent to the location of their farms. The distance of farm to homestead is expected to negatively correlate with the level of CSA adoption, as longer distances can reduce the commitment of farmers to their farming activities. Contact with agricultural extension agents was measured as the number of yearly visits of extension workers to the respondents, either at home or on the farm. Onyeneke *et al.* (2018) opined that extension services are essential sources of information for climate change adaptation and resilience. Contact with agricultural extension workers is anticipated to positively correlate with the level of CSA adoption. Exposure to media was captured as a continuous variable and measured as the number of mass media outfits accessed. Exposure to media was expected to positively correlate with the level of CSA adoption.

Gender of the respondent was captured in the model as a categorical (dummy) variable, with male coded as 1 and female as 0. Simelane (2017) points out that small-scale farming in South Africa is practised primarily at the local level by women. However, Elias *et al.* (2013) argue that equal participation of men and women in agriculture would enhance agricultural production. Given this debate, the effect of gender on the level of CSA adoption could not be predetermined. Marital status of the respondent was also captured in the model as a dummy variable, where a married respondent is assigned a numeric value of 1 and 0 if otherwise. The effect of the marital status of the respondents on the CSA adoption could not be predetermined.

Agricultural Production activity was captured as a dummy variable, where respondents practising mixed farming are assigned a numeric value of 1, while those engaged in a one enterprise activity are assigned a value of 0. The effect of the nature of the production activity of the respondents on the level of CSA adoption could not be predetermined. Membership of an agricultural-related group was captured as whether the respondents belong to an

agricultural-related group or association or not, where those who belong to one group or the other were assigned a numeric value of 1 and 0 if otherwise. Belonging to an agricultural-related group was anticipated to have a positive correlation with the level of CSA adoption. Perception of the effect of climate change was captured as a dummy variable and measured by assigning a numeric value of 1 to the respondents who perceived that climate change has a significant adverse effect on agricultural production and 0 to those who think otherwise. Vera *et al.* (2017) state that farmers who observed an increase in floods and changes in moisture levels in their area would likely adopt more CSA practices than other farmers. Perception of the effect of climate change is anticipated to have a positive correlation with the level of CSA adoption.

### 5.3 Results

#### 5.3.1 Socio-Economic Characteristics of Respondents

Table 5.2 shows that the age of the sampled farmers in Mthonjaneni Municipality ranged between 29 and 72 years while that of the farmers in uMhlathuze ranged between 30 and 78 years. Results further reveal that the average age of the sampled farmers was 48 and 51 years in Mthonjaneni and uMhlathuze respectively. Results from the combined analysis show that the average age of the sampled farmers in KCDM was 51 years with age ranging between 29 and 78 years. Regarding education status, the years of schooling of the sampled farmers in Mthonjaneni ranged between 0 and 15 years with an average of 6 years, while those in uMhlathuze ranged between 0 and 16 years with an average of 7 years. The average years of schooling of the sampled farmers in KCDM was 7 years with their years of schooling ranging between 0 and 16 years. The size of a household in Mthonjaneni Municipality ranged between 5 and 18 members with an average size of 9 members while that of uMhlathuze ranged between 3 and 17 members with an average size of 9 members. Table 5.2 summarizes the socio-economic characteristics (continuous variables) of the sampled small-scale farmers in the study area/ s.

Table 5. 2: Socio-Economic Characteristics (continuous variables) of the sampled Farmers

Variable	Mthonjaneni				uMhlathuze				Combined Analysis (KCDM)			
	Mean	Max	Min	SD	Mean	Max	Min	SD	Mean	Max	Min	SD
Age	48.2	72	29	13.1	51.7	78	30	10.7	50.5	78	29	11.1
Education status (years of education)	5.7	15	0	5.2	7.4	16	0	5.1	6.5	16	0	5.0
Household size	8.7	18	5	3.5	8.7	17	3	3.1	8.7	18	3	3.2

Average monthly farm income	1299.6	4100	500	937.8	1372.8	4350	600	908.0	1348	4350	500	917.3
Average monthly non-farm income	2417.5	5000	500	3064.1	2610.4	5200	800	2031.1	2622.5	5200	500	2421.3
Farming experience (years of experience)	13.3	46	5	10.6	13.1	50	4	9.7	13.1	50	4	9.9
Distance of farm to homestead	0.6	2.5	0.1	0.5	0.6	2.4	0.1	0.4	0.6	2.5	0.1	0.5
Contact with extension agents	6.9	24	0	5.7	8.1	26	2	5.1	7.7	26	0	5.3
Exposure to media	2.0	4	0	0.8	2.1	4	0	0.8	2.1	4	0	0.8

Source: Survey Data (2018/19)

The average household size of the sampled farmers in KCDM ranged between 3 and 18 members with an average size of 9 members. The average monthly farm income range of the sampled farmers in Mthonjaneni was between ZAR 500 and ZAR 4 100 with an average monthly farm income of ZAR 1 300 while that of uMhlathuze ranged between ZAR 600 and ZAR 4 350 with an average of ZAR 1 373. The monthly farm income of the sampled farmers in KCDM ranged between ZAR 500 and ZAR 4 350 with an average of ZAR 1 348. Average monthly income from sources other than farming (off-farm) activities in Mthonjaneni ranged between ZAR 500 and ZAR 5 000 with an average of ZAR 2 418 while that of uMhlathuze ranged between ZAR 800 and ZAR 5 200 with an average of ZAR 2 610. The average monthly income of the sampled farmers in KCDM from off-farm sources ranged from ZAR 500 to ZAR 5 200 with an average of ZAR 2 623.

Table 5.2 reveals that the sampled farmers in Mthonjaneni Municipality had an average of 13 years of farming experience ranging from 5 to 46 years while that of their counterparts in uMhlathuze ranged between 4 and 50 years with an average of 13 farming years of experience. The average years of farming experience of the sampled farmers in KCDM was also 13 years with their years of farming experience ranging between 4 and 50 years. The average distance of farm to the homestead of the sampled farming households in Mthonjaneni was 0.6km, with the distance ranging from 0.1 to 2.5km. The average distance of farm to homestead of the sampled farming households in uMhlathuze was also 0.6km, but the distance in uMhlathuze ranged between 0.1 and 2.4km. Results from the combined analysis reveal that the average distance of farm to homestead of the sampled farming households in KCDM was 0.6km, while the distance ranged between 0.1 and 2.5km.

The sampled farmers in Mthonjaneni had an average of 7 contacts with extension agents in the completed season preceding the survey, with the number of contacts they had with extension

agents ranging from 0 to 24 times, while their counterparts in uMhlathuze had an average of 8 contacts with extension agents in the completed season preceding the survey, with the number of contacts ranging from 0 to 26 times. Results from the combined analysis reveal an average of 8 extension contacts with the sampled farmers in KCDM, with the number of extension contacts ranging between 0 and 26 times. The sampled farmers' exposure to media was assessed by their exposure to radio, television, newspaper and internet. A value of 1 was assigned each to access to any of the media outfit considered. The average number of media outfits the sampled farmers were exposed to was 2 in both municipalities with the number of media outfits ranging between 0 and 4. Results from the combined analysis reveal exposure to an average of 2 media outfits for the sampled farmers in KCDM, with the number of outfits of the sampled farmers in KCDM also ranging from 0 to 4 (Table 5.2).

Table 5.3 reveals the gender distribution of the sampled small-scale farmers. Female farmers accounted for the majority (56% and 58%) in Mthonjaneni and uMhlathuze respectively. The combined analysis also shows that females were the dominant (58%) group from the sampled farmers in KCDM. Results further reveal that the majority (about 56% and 58%) of the sampled farmers in Mthonjaneni and uMhlathuze respectively were married. Results from the combined analysis also show that the majority (58%) of the sampled farmers in KCDM were married. The majority (59%) of the farmers in Mthonjaneni practised mixed farming, whereby the integrated livestock production with crop production, while the majority (63%) of their counterparts in uMhlathuze were involved in one enterprise activity, whereby they were solely into either crop or livestock production. The combined analysis reveals that the majority (62%) of the farmers were into one enterprise activity. About 60 per cent of the sampled farmers in Mthonjaneni agreed to belong to one agricultural-related group or the other, while only 46 per cent of their counterparts in uMhlathuze claimed to belong to one agricultural-related group or the other. Results from the combined analysis revealed that a higher proportion (51%) of the sampled farmers in KCDM claimed to belong to one agricultural-related group or the other. Table 5.3 summarizes the socio-economic characteristics (categorical variables) of the sampled small-scale farmers in the study area/ s.

Table 5. 3: Socio-Economic Characteristics (categorical variables) of the sampled Farmers

<b>Variable</b>	<b>Mthonjaneni</b>	<b>uMhlathuze</b>	<b>Combined Analysis (KCDM)</b>
	<b>Percentage</b>	<b>Percentage</b>	<b>Percentage</b>
<b>Gender</b>			
Male	44.0	41.7	42.5
Female	56.0	58.3	57.5
<b>Marital Status</b>			

Not married (single, divorced/separated or widowed)	44.0	41.7	42.6
Married	56.0	58.3	57.5
<b>Agricultural Production Activity</b>			
Mixed farming (crop and livestock production)	58.7	37.2	38.5
One enterprise activity (crop production or livestock production)	41.3	62.9	61.5
<b>Membership of an agricultural-related group</b>			
Yes	59.6	45.9	50.5
No	40.4	54.1	49.5
<b>Perception of the effect of climate change</b>			
Significant adverse effect	56.9	49.1	51.7
No significant adverse effect	43.1	50.9	48.3

Source: Survey Data (2018/19)

Results on the perception of the sampled farmers of climate change show that about 57 per cent of the sampled farmers in Mthonjaneni perceived climate change to have a significant adverse effect on agricultural production while about 49 of their counterparts in uMhlathuze Municipality shared similar perception. Results from the combined analysis reveal about 52 per cent of the sampled farmers in KCDM perceived climate change to have significant adverse effect on agricultural production (Table 5.3).

### 5.3.2 Category of Respondents based on the Level of use of Climate-Smart Agricultural Practices

The composite score generated from the responses of the sampled small-scale farmers on their level of use of CSA practices was used to classify the farmers into three categories; that is low, medium and high users. Results from the composite score analysis reveal that more than half (55% and 57%) of the sampled small-scale farmers fell into the category of medium users in Mthonjaneni and uMhlathuze respectively. About 20 and 17 per cent were in the high user category in Mthonjaneni and uMhlathuze respectively. About 26 per cent were in the lower user category in both municipalities. Results from the combined analysis also reveal that the majority (57%) of the sampled small-scale farmers were medium users, while 26 and 18 per cent were low users of CSA practices (Table 5.4). Table 4 summarizes the categories of sampled farmers based on the level of use of CSA practices.

Table 5. 4: Categories of respondents by their level of use of Climate-Smart Agricultural Practices

Category of Users	Mthonjaneni		uMhlathuze		Combined Analysis	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage

Low User	28	25.7	56	25.7	84	25.7
Medium User	60	55.0	125	57.3	185	56.6
High User	21	19.3	37	17.0	58	17.7
Total	109	100.0	218	100.0	327	100.0

Source: Survey Data (2018/19)

### 5.3.3 Factors Influencing the Level of Adoption of Climate-Smart Agricultural Practices

#### *Diagnostic test*

A diagnostic test was performed to check the proportional odds assumption in the models used. A test was run for the model fit for Mthonjane, uMhlathuze and the combined analysis (KCDM). The null hypothesis is that there is no difference in the coefficients between models. Results on the proportional odds assumption, as shown in Table 5.5 indicate that there are significant differences in the coefficients in the models. The results from the Brant test, as shown in Table 5.6, also establishes that the proportional odds assumption or the parallel regression assumption has been violated. The observations from the two results (Table 5.5 and 5.6) imply that the proportional odds assumption or the parallel regression assumption has been violated. Therefore, a generalized ordered logistic model is adopted.

Table 5. 5: Likelihood-Ratio Test of Proportionality of Odds

Variable	Mthonjaneni			uMhlathuze			Combined Analysis (KCDM)			
	Coefficient	Std. Err.	P >  z	Coefficient	Std. Err.	P >  z	Coefficient	Std. Err.	P >  z	
Age	-0.0052	0.0220	0.812	0.0082	0.0165	0.618	0.0121	0.0122	0.321	
Educational status	0.0199	0.0533	0.709	0.0558	0.3189	0.080	0.0399	0.0251	0.112	
Household size	0.0792	0.0788	0.315	-0.0251	0.0533	0.638	-0.0226	0.0416	0.587	
Average monthly farm income	0.0063	0.0035	0.072	0.0009	0.0023	0.684	0.0027	0.0019	0.153	
Average monthly off-farm income	-0.0032	0.0016	0.042	0.0001	0.0010	0.961	-0.0008	0.0007	0.264	
Farming experience	0.0007	0.0224	0.975	-0.0161	0.0163	0.322	-0.0153	0.0125	0.221	
The distance of farm to homestead	0.3177	0.4213	0.451	-0.9136	0.3586	0.011	-0.3980	0.2504	0.112	
Contact with agricultural extension agents	-0.0466	0.0387	0.228	0.0223	0.0289	0.441	-0.0107	0.0219	0.624	
Exposure to media	0.0065	0.2809	0.9810	-0.0324	0.1741	0.8520	0.0275	0.1429	0.8470	
Gender	-0.1727	0.4728	0.715	-0.2240	0.2827	0.428	-0.1601	0.2305	0.487	
Marital Status	0.4179	0.2798	0.881	-0.0652	0.1618	0.687	-0.0206	0.1333	-0.877	
Agricultural Production activity	1.0396	0.2651	0.000	0.0318	0.1546	0.837	0.2609	0.1257	0.038	
Membership to an agricultural-related association or group	-0.0915	0.3605	0.800	0.1779	0.2803	0.526	0.0815	0.2101	0.698	
Perception of the effect of climate change	-1.0292	0.4460	0.0210	-0.0443	0.2820	0.8750	-0.3189	0.2265	0.1590	
_ Cut1	0.1952	1.5358	(Ancillary parameters)	-1.1649	1.1581	(Ancillary parameters)	-0.5165	0.8724	(Ancillary parameters)	
_ Cut2	3.7257	1.6070		1.6615	1.1619		2.2464	0.8825		
<i>Approximate likelihood-ratio test of proportionality of odds across response categories</i>										
			<i>Chi2(14) = 33.23</i>				<i>Chi2(14) = 12.27</i>			
			<i>Prob &gt; Chi2 = 0.0027</i>				<i>Prob &gt; Chi2 = 0.0448</i>			
							<i>Chi2(14) = 27.04</i>			
							<i>Prob &gt; Chi2 = 0.0190</i>			

Source: Survey Data (2018/19) computed from STATA 14

Table 5. 6: Brant Test of Parallel Regression Assumption

Variable	Mthonjaneni			uMhlathuze			Combined Analysis (KCDM)		
	Chi2	p>chi2	Df	Chi2	p>chi2	df	Chi2	p>chi2	df
	<b>24.53</b>	<b>0.040</b>	<b>14</b>	<b>11.85</b>	<b>0.619</b>	<b>14</b>	<b>29.02</b>	<b>0.010</b>	<b>14</b>
Age	0.14	0.711	1	1.75	0.186	1	1.50	0.221	1
Educational status	0.77	0.379	1	1.24	0.265	1	2.47	0.116	1
Household size	0.06	0.807	1	0.34	0.561	1	0.06	0.808	1
Average monthly farm income	0.01	0.932	1	0.00	0.982	1	0.00	0.996	1
Average monthly off-farm income	2.62	0.106	1	0.32	0.569	1	3.24	0.072	1
Farming experience	0.53	0.468	1	0.69	0.408	1	0.23	0.628	1
The distance of farm to homestead	0.07	0.785	1	0.29	0.589	1	0.20	0.653	1
Contact with agricultural extension agents	1.99	0.158	1	0.11	0.741	1	0.04	0.843	1
Exposure to media	2.07	0.150	1	1.56	0.212	1	3.61	0.057	1
Gender	3.90	0.048	1	0.03	0.860	1	1.03	0.310	1
Marital status	4.79	0.029	1	0.18	0.675	1	2.16	0.142	1
Agricultural Production activity	5.45	0.020	1	0.04	0.835	1	4.00	0.045	1
Membership to an agricultural-related association or group	0.45	0.505	1	0.01	0.906	1	0.52	0.473	1
Perception of the effect of climate change	10.13	0.001	1	2.97	0.085	1	9.32	0.002	1

A significant test statistic provides evidence that the parallel regression assumption has been violated

Source: Survey Data (2018/19)

### ***The result from the Generalized Ordered Logit Regression***

The dependent variable of the model is the category of users of CSA practices (high, medium and low), where the high user category is the reference category in the model. Internally, the generalized ordered logit regression generated constraints on the parameters. All the variables in the model fitted for the regression analysis of the responses from uMhlathuze and the combined analysis (KCDM) were constrained to have their effects satisfy the proportional odds or parallel lines assumptions. However, for the regression model fitted for the responses from Mthonjaneni, gender, marital status, agricultural production activity and perception on the impact of climate change could not satisfy the parallel lines assumption. The difference is only in the interpretation of the parameters of those that do not eventually satisfy the parallel lines assumption. Interpretation is particularly straightforward for those variables that satisfy the parallel lines assumption.

Table 5.7 shows that educational status is statistically significant and has a positive influence on the level of adoption of CSA practices among the sampled small-scale farmers in the lower and medium user categories at 10 per cent ( $p = 0.080$ ) level of significance in uMhlathuze Municipality, whereas it has no statistically significant influence in Mthonjaneni nor for the combined analysis (KCDM). This finding implies that an increase in the level of education for the sampled small-scale farmers in the lower and medium user categories in uMhlathuze, would increase their level of adoption of CSA practices.

The average monthly farm income of the sampled small-scale farmers has a statistically significant and positive influence on the level of adoption of CSA practices in the lower and medium user categories in Mthonjaneni at 5 per cent level of significance ( $p = 0.015$ ) but has no statistically significant influence in uMhlathuze nor for the combined analysis (KCDM). This result implies that an increase in average monthly farm income of the sampled farmers in the lower and medium user categories in Mthonjaneni would increase their level of adopting CSA practices. Table 5.7 summarizes the results of the factors affecting the level of adoption of CSA practices among the sampled farmers.

Table 5. 7: Results of the factors influencing the level of adoption of CSA practices by the respondents

Variable/Category	Mthonjaneni			uMhlathuze			Combined Analysis (KCDM)		
	Coefficient	Std. Err.	P >   z	Coefficient	Std. Err.	P >   z	Coefficient	Std. Err.	P >   z
<b>Low</b>									
Age	-0.0057188	0.0244528	0.815	0.0082436	0.0165233	0.618	-0.0028472	0.0140992	0.840
Educational status	0.0309579	0.0572622	0.589	0.0557751*	0.0318942	0.080	0.009173	0.0293725	0.755
Household size	0.0478159	0.0838986	0.569	-0.0251191	0.053335	0.638	-0.0213722	0.0418183	0.609
Average monthly farm income	0.0060014**	0.0038025	0.015	0.0009321	0.0022929	0.684	0.0024922	0.0018975	0.189
Average monthly off-farm income	-0.0033276**	0.0016799	0.048	-0.000051*	0.0010381	0.061	-0.000743**	0.0007565	0.026
Farming experience	-0.0073988	0.0260523	0.776	0.0161345**	0.0163012	0.032	0.0854914**	0.0332065	0.010
The distance of farm to homestead	0.3192558	0.4757291	0.502	-0.913615***	0.3586368	0.011	-0.4121631*	0.2533313	0.104
Contact with agricultural extension agents	0.0549592**	0.0431383	0.023	0.0223367**	0.0289947	0.041	0.0144521**	0.0225862	0.052
Exposure to media	0.0122635**	0.2930166	0.037	0.0324539**	0.174123	0.052	0.0439566*	0.1445082	0.061
Gender	-0.6943115	0.6100342	0.255	-0.2240656	0.2827779	0.428	-0.1698881	0.2344702	0.469
Marital status	0.9474023**	0.3636183	0.054	-0.0652167	0.1618485	0.687	-0.0156954	0.1399762	0.911
Agricultural Production activity	1.891499***	0.3266821	0.001	0.0318254	0.154604	0.837	0.4821539***	0.1656814	0.004
Membership to an agricultural-related association or group	-0.0115301	0.4308969	0.979	0.1779649**	0.28031	0.026	0.0667765*	0.2172396	0.059
Perception of the effect of climate change	0.3305275**	1.827168	0.036	0.0442666*	0.2820044	0.075	0.825035***	0.2776739	0.003
Constant	3.006088	1.827169	0.100	1.164857	1.158169	0.315	2.147514	0.9922936	0.030
<b>Medium</b>									
Age	-0.0057188	0.0244528	0.815	0.0082436	0.0165233	0.618	-0.0028472	0.0140992	0.840
Educational status	0.0309579	0.0572622	0.589	0.0557751*	0.0318942	0.080	0.009173	0.0293725	0.755
Household size	0.0478159	0.0838986	0.569	-0.0251191	0.053335	0.638	-0.0213722	0.0418183	0.609
Average monthly farm income	0.0060014**	0.0038025	0.015	0.0009321	0.0022929	0.684	0.0024922	0.0018975	0.189
Average monthly off-farm income	-0.0033276**	0.0016799	0.048	0.000051	0.0010381	0.061	-0.000743**	0.0007565	0.026
Farming experience	-0.0073988	0.0260523	0.776	0.0161345**	0.0163012	0.032	0.0854914**	0.0332065	0.010
The distance of farm to homestead	0.3192558	0.4757291	0.502	-0.913615***	0.3586368	0.011	-0.4121631*	0.2533313	0.104
Contact with agricultural extension agents	0.0549592**	0.0431383	0.023	0.0223367**	0.289947	0.041	0.0144521**	0.0225862	0.052
Exposure to media	0.0122635**	0.2930166	0.037	0.0324539**	0.174123	0.052	0.0439566*	0.1445082	0.061

Gender	1.277221	0.8573006	0.136	-0.2240656	0.2827779	0.428	-0.1698881	0.2344702	0.469
Marital status	0.3442117*	0.4913061	0.059	-0.0652167	0.1618485	0.687	-0.0156954	0.1399762	0.911
Agricultural Production activity	0.5381778**	0.5668445	0.049	0.0318254	0.154604	0.837	0.4821539***	0.1656814	0.004
Membership to an agricultural-related association or group	-0.0115301	0.4308969	0.979	0.1779649**	0.28031	0.026	0.0667765*	0.2172396	0.059
Perception of the effect of climate change	2.236169***	0.6473859	0.001	0.0442666*	0.2820044	0.075	0.825035***	0.2776739	0.003
Constant	-9.358094	2.72822	0.001	-1.661546	1.161911	0.153	2.147514	0.9922936	0.030
Number of observations		108			216			324	
LR Chi2 (14)		63.26			14.06			38.68	
Prob > Chi2		0.0000			0.0051			0.0031	
PseudoR2		0.2954			0.2338			0.0613	

\*\*\*, \*\*, \* denotes statistical significance at 1; 5 & 10 % level

The high user category was generated as the reference category

Source: Survey Data (2018/19) computed from STATA 14

The average monthly off-farm income has a statistically significant and negative influence on the level of adoption of CSA practices at 5 per cent ( $p = 0.048$ ) and 10 ( $p = 0.061$ ) level of significance of the sampled farmers in the lower and medium user categories in Mthonjaneni and uMhlathuze respectively (Table 5.7). Results from the combined analysis (KCDM) also show a statistically significant and negative influence at 5 per cent ( $p = 0.026$ ) level of significance. This implies that an increase in monthly off-farm income would decrease the level of adoption of CSA practices by the sampled small-scale farmers in both municipalities.

Results in Table 5.7 further show that farming experience has a statistically significant and positive influence on the level of adoption of CSA practices of the sampled farmers in the lower and medium user categories at 5 per cent ( $p = 0.032$  and  $p = 0.010$ ) level of significance in uMhlathuze and for the combined analysis (KCDM) respectively. However, farming experience has no statistically significant influence on the level of adoption of CSA practices in Mthonjaneni. This implies that an increase in the years of farming experience would increase the level of adoption of CSA practices of small-scale farmers.

The distance of the farm to homestead has a statistically significant and negative influence on the level of adoption of CSA practices of the sampled farmers in the lower and medium user categories in uMhlathuze at 5 per cent ( $p = 0.104$ ) level of significance (Table 5.7). Results from the combined analysis (KCDM) show that the distance of the farm to homestead has a marginal statistically significance and negative influence at 10 per cent ( $p = 0.104$ ) level of significance on the level of CSA adoption. This implies that an increase in distance to the farm location from homestead would decrease the level of adoption of CSA practices.

Table 5.7 reveals that contact with agricultural extension agents is statistically significant and positively influences the level of adoption of CSA practices among the sampled farmers in the lower and medium user categories at 5 per cent ( $p = 0.023$ ,  $p = 0.041$  and  $p = 0.052$ ) level of statistical significance in Mthonjaneni, uMhlathuze and for the combined analysis (KCDM) respectively. This finding implies that an increase in contact with agricultural extension agents would increase the level of adoption of CSA practices.

Table 5.7 further shows that exposure to media is statistically significant and positively influences the level of adoption of CSA practices among the sampled farmers in the lower and medium user categories at 5 per cent ( $p = 0.035$  and  $p = 0.052$ ) and 10 percent ( $0.061$ ) level of significance in Mthonjaneni, uMhlathuze Municipalities and for the combined analysis

(KCDM) respectively. The results imply that an increase in the level of exposure to media would increase the level of adoption of CSA practices.

Table 5.7 also shows that marital status has a statistically significant positive influence on the level of adoption of CSA for the sampled farmers in Mthonjaneni at 5 per cent ( $p = 0.054$ ) and 10 per cent ( $p=0.059$ ) level of significance in the lower and medium user categories respectively (the variable marital status for the sampled farmers in Mthonjaneni did not satisfy the parallel lines assumption). Marital status has no statistically significant influence on the level of CSA adoption of the sampled farmers in uMhlathuze nor for the combined analysis (KCDM).

Results in Table 5.7 show that agricultural production activity has a statistically significant and positive influence on the level of adoption of CSA of the sampled farmers in Mthonjaneni at 1 per cent ( $p = 0.001$ ) and 5 per cent ( $p = 0.049$ ) in the lower and medium user categories respectively (the variable agricultural production activity for the sampled farmers in Mthonjaneni did not satisfy the parallel lines assumption). The agricultural production activity also has a 1 per cent ( $p = 0.004$ ) level of statistical significance in the combined analysis (KCDM). In contrast, agricultural production activity has no statistically significant influence on the level of CSA adoption in uMhlathuze.

Membership to an agricultural-related association or group was found to be statistically significant and positively influences the level of adoption of CSA practices among the sampled farmers in the lower and medium user categories in uMhlathuze at 5 per cent ( $p = 0.026$ ) level of significance, but has no statistically significant influence on the level of CSA adoption in Mthonjaneni nor for the combined analysis (KCDM) [Table 5.7].

Table 5.7 shows that the perception of the effect of climate change has a statistically significant and positive influence on the level of CSA adoption in Mthonjaneni at 5 per cent ( $p = 0.036$ ) and 1 per cent ( $p = 0.001$ ) in the lower and medium user categories (the variable perception of the effect of climate change for the sampled farmers in Mthonjaneni did not satisfy the parallel lines assumption). Perception of the effect of climate change is also significant at 5 per cent ( $p = 0.075$ ) and 1 per cent ( $0.003$ ) level of significance in uMhlathuze and for the combined analysis (KCDM) respectively. The results imply that small-scale farmers who perceive that climate change has an adverse effect would adopt more CSA practices.

## 5.4 Discussion

The aim of this paper is to assess the factors affecting the level of adoption of CSA practices by small-scale farming households in KCDM from two selected local municipalities, namely Mthonjaneni and uMhlathuze. Results of the category of the respondents based on their level of use of CSA practices reveal a similar pattern in both municipalities. The majority of the respondents fell into the medium user category while the least proportion fell into the high user category. However, there is a higher proportion of respondents in the high user category in Mthonjaneni compared to uMhlathuze. These findings suggest that the sampled small-scale farmers in Mthonjaneni are better adopters of CSA practices than those in uMhlathuze.

The results show a similar pattern in age distribution in the sampled small-scale farmers, revealing that there were more aged people involved in farming than youths in both municipalities. The low level of involvement of youths in agriculture could be because they find agriculture unattractive and prefer to search for jobs in other sectors.

Results of the educational status of the sampled farmers in uMhlathuze and Mthonjaneni reveal that they were generally educated. This finding can be attributed to the state of access to education in the two municipalities. The reports from the census conducted in 2001 and 2011, although low, reveal improved access to education in both municipalities over the years and show higher access to education in uMhlathuze than in Mthonjaneni (King Cetshwayo District Municipality, 2017). Educational status was found not to have a statistically significant and positive influence on the level of adoption of CSA practices in Mthonjaneni and KCDM. Education status, however, has a statistically significant positive effect on the level of adoption of CSA practices in uMhlathuze; a result agreeing with the finding of Onyeneke and Nwajiuba (2010) as well as Onyeneke *et al.* (2018) that education positively affects climate change adaptation. Education is expected to increase the capacity of farmers to obtain, process and utilize information relevant to the adoption and management of agricultural practices (Onyeneke *et al.*, 2018). This however contrasts the finding of Wekesa *et al.* (2018) who report a negative influence of years of schooling on the choice of CSA package. Wekesa *et al.* (2018) argue that educated farmers would opt out of a CSA package if it does not offer risk reduction measures which could protect their investment against the risks of climate change.

The results of household size reveal a large average household size for the sampled small-scale farmers in both municipalities and are consistent with the descriptive evidence obtained from the marital status of the respondents. A large household is a potential contributor to the labor

force for agricultural activities, which the farming households in both municipalities could be enjoying (Ojoko *et al.*, 2017). Nonetheless, household size was found to have no statistical significance on the level of adoption of CSA practices in this study.

The results from the combined analysis (KCDM) generally show that the sampled small-scale farmers earn fairly from their agricultural production when compared with the South African national poverty line, which is at an equivalent of ZAR 1 227 in 2019 (Statistics South Africa, 2019). However, results of average monthly farm income show that the farmers in Mthonjaneni earned more than those in uMhlathuze. This corroborates the report that Mthonjaneni has a higher agricultural potential than uMhlathuze (Municipal Directory of South Africa, 2017). Average monthly income was found to have a statistically significant and positive influence on the level of adoption of CSA practices. Average monthly farm income, however, has a statistically significant positive effect on the level of adoption of CSA practices in Mthonjaneni. Income from farming activities tends to increase the level of adoption of CSA practices by the farmers probably because farmers with higher farm income are less risk-averse and have better exposure to information (Knowler & Bradshaw, 2007; Onyeneke *et al.*, 2018). This result is in line with the finding of Onyeneke *et al.* (2018) that there is an increased likelihood for the adjustment of the agricultural production systems with an increase in farm income. Vera *et al.* (2017), Wollni *et al.* (2010) and Katengeza *et al.* (2012) also confirm a statistically significant positive influence of farm income on the intensity of adoption of technologies and climate change adaptation.

Results of income from other sources than farming (off-farm income) show that the sampled farmers from uMhlathuze Municipality had a higher average income from alternative sources than those in Mthonjaneni. This could be because there are more economic activities in uMhlathuze (Municipal Directory of South Africa, 2017). Such activities, among others, include trading, handwork and cleaning. Average monthly off-farm income was found to have a statistically significant and negative influence on the level of adoption of CSA practices in this paper for both municipalities which is also the case for the combined analysis (KCDM). A flourishing alternative source of income could result in a weak commitment to agricultural production. This result is in line with the finding of Vera *et al.* (2017) that income generation from sources other than farming reduces the likelihood of the adoption of more CSA practices. Farmers who can diversify their sources of income can generally deal with agricultural production shocks and may see no need to improve the resilience of their agricultural production through the adoption of more CSA practices (Vera *et al.*, 2017).

Generally, the results show a higher farming experience for the sampled small-scale farmers in KCDM. However, there is a higher proportion of farmers with more years of farming experience in Mthonjaneni than uMhlathuze which could account for the higher agricultural potential reported for Mthonjaneni (Municipal Directory of South Africa, 2017). The farming experience was found to have a statistically significant and positive influence on the level of adoption of CSA practices in this study for uMhlathuze which is also true for the combined analysis (KCDM). This implies that an increase in the years of farming experience would increase the level of CSA adoption. According to Onyeneke *et al.* (2018), farming experience significantly increases the likelihood of adjusting agricultural production and management systems. The result suggests that involving experienced farmers in promoting CSA among small-scale farmers can substantially impact the uptake of various CSA practices and enhance the implementation of CSA-related programs and projects among small-scale farmers.

Results of the distance of farm to homestead reveal the same average distance for Mthonjaneni, uMhlathuze and the combined analysis (KCDM). This finding could be attributed to the similarity in the nature of settlement in both municipalities, which is expected since they are inhabited by the same group of people (Lehohla, 2016; Municipal Directory of South Africa, 2017). The distance of farm to the homestead of the sampled small-scale farmers in uMhlathuze has a statistically significant and negative effect on level of CSA adoption which is also true for the combined analysis (KCDM). This implies that farmers whose farms are far from their homesteads would likely adopt fewer CSA practices. This could be attributed to the challenges they would be facing in exercising proper and effective management as a result of the stress posed by distance compared to their counterparts who live closer to their farms. According to Teklewold *et al.* (2013), besides influencing market accessibility, distance can also affect important factors critical to agricultural production such access to technologies, information and credit institutions.

Results of contact with extension agents reveal that the sampled farmers in uMhlathuze, on average, had more extension contacts than their counterparts in Mthonjaneni. Access to extension services and advisory roles plays an essential role in the enhancement of adoption and innovation (Wekesa *et al.*, 2018). Contact with agricultural extension agents has a statistically significant and positive effect on the level of adoption of CSA practices of the sampled small-scale farmers in both municipalities. This finding is also true for the combined analysis (KCDM). Agricultural extension services serve as a crucial source of information on climate change, climate change adaptation and resilience, as well as agricultural management

practices (Onyeneke *et al.*, 2018). This result agrees with the finding of Onyeneke *et al.* (2018) that contact with extension agents increases the likelihood of the adoption of CSA practices. It is expected that frequent contact with extension agents would brighten the chances of awareness of climate change and CSA practices that can be adopted to adapt to climate variability and shocks. Besides, farmers, through extension services, can learn climate change mitigation measures and strategies that can enhance resilience.

Results on exposure to media show that the sampled farmers in Mthonjaneni, uMhlathuze and the combined analysis (KCDM), on average, had the same level of exposure to media outfits. Exposure to media is statistically significant and positively affect the level of CSA adoption of the sampled small-scale farmers in both Mthonjaneni and uMhlathuze Municipalities. This finding is also true for the combined analysis (KCDM). Onyeneke *et al.* (2018), in their study, also established that exposure to mass media increases the probability of the uptake of CSA practices. Exposure to media denotes that farmers who have considerable access to information through the media have a better chance of awareness of the impacts of climate change and how to respond swiftly.

Results of gender show that a higher proportion of the sampled farmers in both municipalities were female. These results are consistent with the findings of Simelane (2017), Kutya (2012) and Masuku (2013) who also observed that small-scale farming in South Africa is practised primarily at a local level by older females. Nieuwoudt and Groenewald (2003) also described small-scale farmers as usually consisting of elderly women. Both age and gender, however, were found to have no statistical significance on the level of adoption of CSA practices in this study.

Results of marital status reveal that more than half of the farmers in Mthonjaneni and uMhlathuze were married. Marital status was found to have a statistically significant and positive influence on the level of adoption of CSA practices in this study. However, results from the inferential analysis show that the married farmers in Mthonjaneni would adopt more CSA practices, but where they differ most from their counterparts with a different marital status is that they are less likely to be in the low user category. This finding could be because married farmers are more tenacious about their agricultural production due to family responsibilities. This contrasts with the findings of Ojoko *et al.* (2017) who reported that marital status has no significant effect on the level of CSA adoption among small-scale farmers.

Generally, the results show that there was a higher proportion of the sampled farmers that were integrating crop and livestock production in Mthonjaneni compared to uMhlathuze. Production activity was found to have a statistically significant and positive influence on the level of adoption of CSA practices in this study for Mthonjaneni as is also true for the combined analysis (KCDM). Results of the influence of production activity reveal that the sampled small-scale farmers who practise mixed farming would adopt more CSA practices than their counterparts who are engaged in a single enterprise activity. The finding suggests that small-scale farmers who are more open to the integration of different farming techniques would adopt more CSA practices compared to their counterparts who rely solely on one farming enterprise. Being open to the combination of varying farming techniques creates a promising and conducive platform for mainstreaming CSA (Wekesa *et al.*, 2018).

Results of membership of an agricultural-related group show that there were more farmers who belong to an agricultural-related group in Mthonjaneni than in uMhlathuze. The combined analysis indicates that there were more sampled farmers in KCDM who belong to an agricultural-related group than those who do not. Membership of agricultural groups plays crucial roles in the enlightenment of their members (Ojoko *et al.*, 2017) and was found to have a statistically significant and positive influence on the level of adoption of CSA practices in this study for uMhlathuze. The result implies that the sampled farmers in both the lower and medium user categories who belong to an agricultural-related association or group would adopt more CSA practices than their counterparts who do not. This is because agricultural associations or groups represent a platform to discuss their challenges with their colleagues, thereby offering the benefit of ideas on how to cope with problems. Part of the benefits they might enjoy is exposure to information on climate change adaptation which they might get as advice from their colleagues (Ojoko *et al.*, 2017).

Results of the perception of the sampled farmers of the effect of climate change show that there were more sampled farmers who perceived climate change to have an adverse effect on agricultural production in Mthonjaneni than in uMhlathuze. The combined analysis indicates that there were more farmers in KCDM who perceived climate change to have an adverse effect than those who did not. Perception of the effect of climate change was found to have a statistically significant and positive influence on the level of adoption of CSA practices for Mthonjaneni and uMhlathuze Municipalities. This finding is also true for the combined analysis (KCDM). Results show that the sampled small-scale farmers who perceive that climate change has a significant adverse effect on agricultural production and food systems would

adopt more CSA practices. This correlates with the finding of Vera *et al.* (2017) that farmers who observed an increase in floods and changes in moisture levels in their area had a higher probability of adopting more CSA practices. This finding is expected, considering that farmers who appreciate the risk attached to extreme weather condition and varying weather pattern see the essence of adopting CSA practices to enhance their resilience to climatic shocks. However, based on the results, there is a difference in the matter of degree of the adoption practices. In Mthonjaneni, adopters are less likely to be in the low user category.

## **5.5 Conclusion and Policy Implications**

There are few studies on the factors affecting the level of CSA adoption among South African small-scale farmers. This study fills this gap by identifying those factors among small-scale farming households in the two selected municipalities in KCDM. The adoption of CSA practices, despite the benefits, is not automatic among small-scale farmers. This study finds that factors such as education, farm income, income from non-farm sources, distance from home to farmstead, contact with agricultural extension agents, exposure to media, marital status, production activity, membership of an agricultural-related group and perception of the effect of climate change are significant determinants of CSA adoption level among small-scale farmers. The results of this study are critical to the government and other stakeholders in the agricultural sector for the mitigation of GHG emissions and they have implications for further research as well as policy design and implementation.

These findings can be used to inform policymakers and the DARD on best practices in mainstreaming CSA into the small-scale farming sector. Improving and strengthening contact with agricultural extension agents, increased exposure to media, and raising awareness on the impacts of climate change are critical in promoting the level of adoption of CSA practices. The implication is that adequate attention should be given to extension services among small-scale farmers in South Africa as frequent extension visits and services may primarily be very useful in mainstreaming the adoption of CSA practices. Furthermore, the use of the media should be intensified in enhancing awareness of the impact of climate change and CSA practices among small-scale farmers.

Stakeholders should endeavor to provide small-scale farmers with CSA-related extension messages. Furthermore, farmers can spread messages and information to their colleagues to ensure a full spread of information on climate change and CSA so that more small-scale farmers can adopt many CSA practices and techniques that will make their agricultural production

systems more productive and resilient to climate change. Available platforms among small-scale farmers, particularly societies or groups, should also be used for these purposes.

A close look at the results reveals that average off-farm income (income from sources other than farming) discourages the adoption of more CSA practices. This suggests that stable incomes from alternative sources to farming may likely reduce commitment to farming and CSA adoption. Policies should be made towards making agriculture more attractive while incentives should be given to encourage active participation and investment in agriculture particularly to encourage small-scale farmers to adopt more CSA practices.

Concerning the challenge with distance to the farm from homesteads, farmers should be assisted with innovations and incentives that can enhance the proper monitoring of their farms. Furthermore, farmers should be supported to surmount the challenge of transportation where it is a big deal, to encourage easy access to their farms and markets for efficient productivity.

Greater attention should be given to integrating crop and livestock enterprises which is critical in promoting CSA adoption. This is because small-scale farmers who practise mixed (integrated) farming are likely to be more open to various CSA practices than their counterparts involved in one farming enterprise activity. While this paper determined the factors influencing the level of adoption of CSA practices among small-scale farmers in two selected municipalities in KCDM, it is recommended that researchers undertake similar and further research into the factors influencing the level of CSA practices in other locations, but of greater depth while incorporating other indicators not considered in this inquiry. Such studies can also focus on CSA practices within comprehensive farm enterprises.

### **Author Contributions**

V.O.A. conceived and designed the study. V.O.A collected and analyzed the data for the study and drafted the manuscript. M.S. and A.O. supervised the study. M.S and A.O scrutinized and verified the research process, methods and the manuscript. All authors contributed to the outcome of the manuscript.

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**Conflict of interest**

The authors declare no conflict of interests.

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## CHAPTER SIX<sup>3</sup>

### ASSESSING THE APPLICABILITY OF CSA ADOPTION IN THE SMALL-SCALE FARMING SYSTEM OF KING CETSHWAYO DISTRICT MUNICIPALITY

#### Abstract

The much focus on the socio-economic characteristics of farmers in investigating the factors that influence the adoption of agricultural practices among farmers is not holistic in addressing the determinants of adoption of agricultural practices. There is, therefore, the need to investigate the characteristics of agricultural practices which can influence their adoption by farmers. This study examines the applicability of CSA practices in King Cetshwayo district municipality in light of how small-scale farmers perceive the social, technical, economic and environmental compatibility of CSA practices. A multi-stage sampling technique was used for sample selection. Data was generated with the aid of a structured questionnaire from 327 small-scale farmers from two local municipalities (Mthonjaneni and uMhlathuze) based on their agricultural potentials. The data was analyzed using descriptive statistics and ALI. Findings reveal that agroforestry, cultivation of cover crops and diet improvement for animals were the highly accepted CSA practices with an ALI scores of 559, 574 and 554 respectively with respect to social compatibility. The use of organic manure (ALI = 545), rotational cropping (ALI = 529), mulching (ALI = 525) and cultivation of cover crops (ALI = 533) were considered technically compatible by the farmers. For economic compatibility, the farmers showed high preference for organic manure (ALI = 542), rotational cropping (ALI = 515) and mulching (ALI = 541), while the use of organic manure (ALI = 524) was considered environmentally compatible. This paper argues that farmers' preferences for CSA technologies differ based on the demonstrable potential benefits and costs of the given technologies. Policies aimed at mainstreaming CSA technologies should pay adequate attention to applicability in the locations under consideration and emphasize the critical role of the provision of information on CSA technologies and practices.

**Keywords:** Acceptance, adoption, climate-smart agriculture, compatibility, economic, environmental, small-scale, social, technical.

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<sup>3</sup> N/B This chapter is prepared as an article for submission to an accredited journal.

\* Text that has already been explained in the methodology chapter will be skipped, with only reference given to.

## 6.1 Introduction

Interest in CSA is rapidly growing in the developing world as a result of its potentials to enhance food security, improve farmers' resilience to the changing climatic conditions and mitigate GHG emissions (FAO, 2013; Lipper *et al.*, 2014). It is particularly important in Africa where the agricultural sector is very vulnerable to changes in climatic condition and where agricultural growth plays a significant role in economic development (Tshuma, 2014; Pereira, 2017). The successes of programs such as Africa CSA alliance notwithstanding, there remains serious need for innovations that combine socio-economic and biophysical realities to mainstream CSA technologies in Africa (Mwongera *et al.*, 2017).

Mainstreaming CSA can be influenced by institutional mechanisms, social and economic factors, resource tenure as well as ecological and climatic conditions (Neufeldt *et al.*, 2015). These influencers are critical players in the adoption of CSA practices at farm or field level (Neufeldt *et al.*, 2015). For example, in the small-scale farming system of underdeveloped and developing countries, where farming is characterized by low inputs, increased productivity and adaptive capacity will be prioritized over increasing carbon sequestration and emission reduction (Campbell *et al.*, 2014). Farmers may be more interested in the applicability and immediate benefits of CSA adoption than the long-term technical benefits it promises (Makate *et al.*, 2018). The applicability of CSA technologies or practices in the context of this study refers to the suitability of these practices in relation to the prevailing condition of the location under consideration. The applicability of these technologies is reflected by their acceptance and prioritization by farmers. However, since the adaptation and mitigation benefits of CSA are complementary and can sometimes be mutually reinforcing, achieving the triple-win effect of CSA is quite possible (Mwongera *et al.*, 2017; Thornton *et al.*, 2018).

The identification, prioritization and applicability of available CSA practices or technologies, in the face of risks from local climatic conditions and the demand for technology are the main challenges for mainstreaming CSA in different agro-ecological zones (Khatri-Chhetri *et al.*, 2017). Identifying and comprehending the applicability of CSA technologies facilitate the planning and design of frameworks and structures meant to help farmers in adapting to changing climatic conditions and improving their resilience (Khatri-Chhetri *et al.*, 2017). There is a need for the consideration of adaptation practices that have been adequately evaluated and prioritized by local farmers in the light of location-specific climate-related risks (Lipper & Zilberman, 2018).

Considering the complexity of farming systems in Africa, there is the need for research that will inform and support adaptation decision making as well as the required agricultural transformation. To maximize proceeds from agricultural investment, particularly in mainstreaming CSA, there is also the need to harness the limited resources systematically in order to optimize the benefits of CSA (Mango *et al.*, 2018). There is, therefore, the need for comprehensive information on the identification and prioritization of locally appropriate CSA practices and the enabling environment needed for the adoption and sustenance of their uptake.

In spite of the above, many CSA programs lack information on adaptation planning and acceptance among farmers. Information and evidence of the applicability of CSA practices or technologies, as well as farmers' approval and prioritization (particularly the local farmers) can assist stakeholders in making strategic decisions that will enhance government policies and institutional arrangements to achieve desired results. It is for this reason that this study examines the social, technical, economic and environmental compatibility of these practices as perceived by the farmers themselves.

## **6.2 Materials and Methods**

### **6.2.1 Study Area**

As earlier stated in chapter four of this thesis, the research study was conducted in KCDM of KZN Province of the Republic of South Africa. Refer to chapter three (section 3.2\*) for the detailed information on the description and selection of study area/ s.

### **6.2.2 Research Design**

A cross-sectional research design was adopted. Refer to chapter three (section 3.7\*) for the detailed information on the description and rationale of the chosen design.

#### ***Conceptual framework***

This paper conceptualizes the applicability of CSA practices through four main components; social compatibility, technical compatibility, economic compatibility and environmental compatibility. Influences on the adoption of agricultural technologies or practices are not limited to the socio-economic characteristics of the farmers. There is insufficient knowledge about variations in the level of adoption of practices which can only be revealed in the factors outside the socio-economic characteristics of farmers. This reveals the need for studies on the

determinants of the adoption of agricultural technologies or practices which focus on the inherent characteristics of the practices and technologies. Such scholarly efforts can have significant influence on the adoption or transfer of CSA technologies and practices. The conceptual framework in Figure 6.1 illustrates the influence of applicability indicators (social, technical, economic and environmental compatibility) on CSA adoption among small-scale farmers.

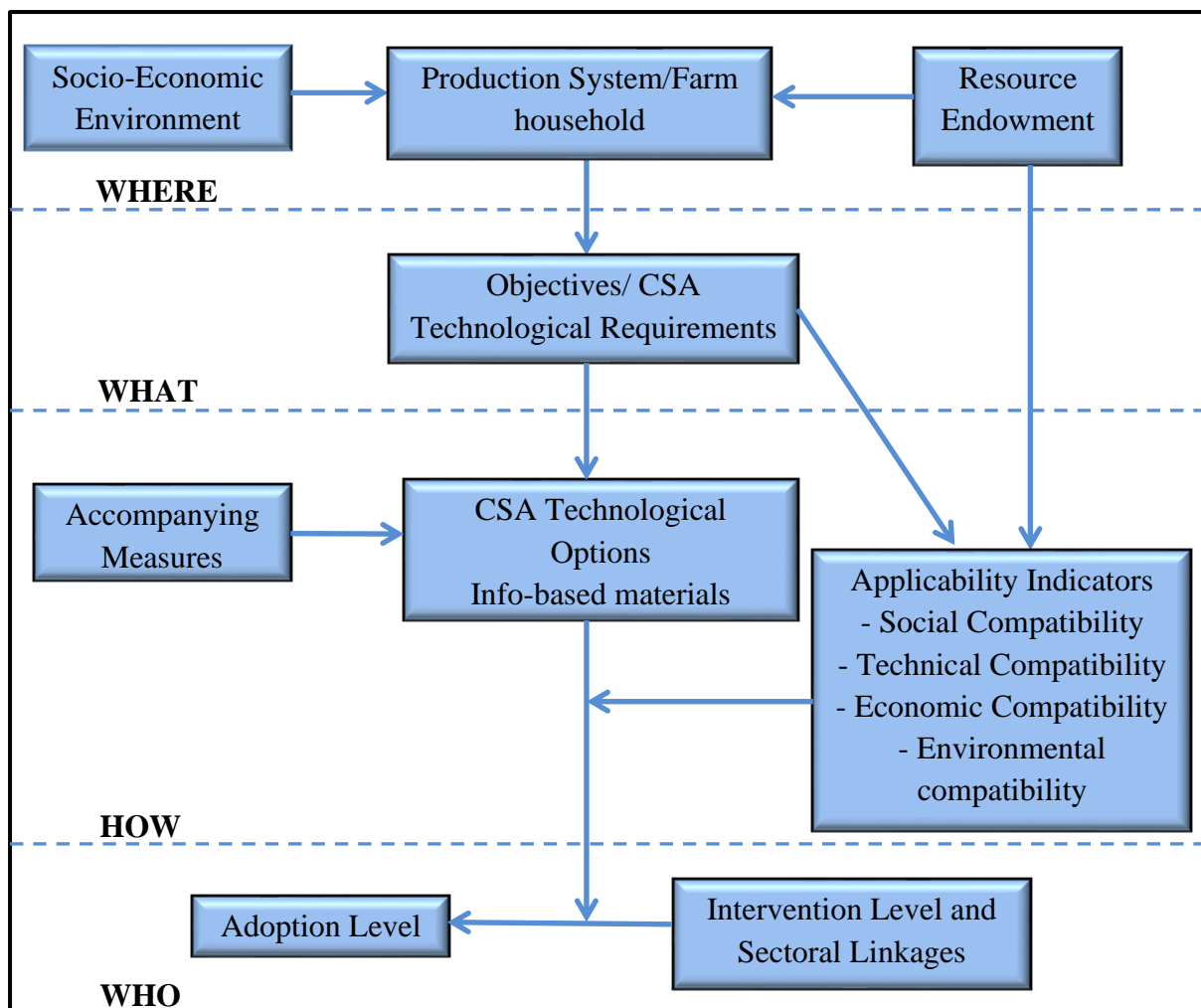


Figure 6. 1: Conceptual framework – Location-Specific Assessment Concept  
 Source: Author’s conceptual design

Technology intervention or introduction does not necessarily result in automatic adoption. There are key elements involved in the transfer or adoption of technologies. The tendency of CSA to be content and location-specific makes the adoption of CSA practices to be more influence-prone (Neufeldt *et al.*, 2015; Lipper & Zilberman, 2018). The location (where) of intervention determines the technological requirements (what) at play which in turn determines the CSA practices that could be adopted. However, in adopting the available practices, potential

adopters will consider the attributes of the CSA technologies or practices and how these are applicable to their conditions (how) in terms of social, technical, economic and environmental compatibility.

The social compatibility of the CSA packages refers to how well the packages are suited to the culture, values and norms of the location in consideration. Technical compatibility refers to the ease of adoption and implementation while economic compatibility relates to the financial implication of adoption. For its part, environmental compatibility is concerned with the likely effect of adoption on the agricultural system and the environment. These factors are entirely dependent on the characteristics of the CSA practices.

### 6.2.3 Sampling Technique and Data Collection

The sampling technique and procedure for data collection is the same as already described in chapter four. Refer to chapter three (section 3.8.1\*) for detailed information on the sample size calculation and data collection procedures.

### 6.2.4 Data Analysis

The applicability of the identified CSA practices in the small-scale farming system was assessed using the ALI. The ALI was adapted from the adaptation strategy use index (Umunna *et al.*, 2013; Mohammed *et al.*, 2014; Ojoko *et al.*, 2017), and was used to analyze the level of acceptance of the identified CSA practices. Farmers were asked to assess CSA practices by using a three-point rating scale 2, 1 and 0 to denote acceptable, neutral and not acceptable, respectively.

The relative level of acceptance of the practices was calculated based on the following index formula

$$ALI = AL_n X 0 + AL_r X 1 + AL_o X 2 \quad (13)$$

where:

*ALI* = Acceptance Level Index

*AL<sub>nt</sub>* = Frequency of farming households who reckoned the climate  
– smart agricultural practices under consideration as not acceptable

*AL<sub>n</sub>* = Frequency of farming households who were indifferent about the climate  
– smart agricultural practices under consideration

$AL_a$  = Frequency of farming households who reckoned the climate  
– smart agricultural practices under consideration as acceptable

With the responses from the sampled farming households, the maximum points for the ALI for each CSA practice can only be 327, 654 and 981 in Mthonjaneni, uMhlathuze Local Municipalities and KCDM respectively and 0 as a minimum point. The farming households were categorized based on their level of acceptance of the CSA practices into high, medium and low (Ojoko *et al.*, 2017);

High user = those whose points fall between 14 and (Mean + S.D) points

Medium user = those between upper and lower categories

Low user = those whose points fall between (Mean – S.D) and 0

How well suited the CSA packages are to the culture and values of the study area/ s were used as a proxy measure for social compatibility, while the ease of adoption was used as proxy measure for technical compatibility. The financial implication of adoption was used as proxy measure for economic compatibility, while the probable effect of adoption on the farming and environmental systems was used as proxy measure for environmental compatibility.

## 6.3 Results

### 6.3.1 Farmers' Perception of the Social Compatibility of CSA Practices

Table 6.1 shows the results obtained from the analysis of the perceptions of the sampled farmers on the social compatibility of the identified CSA practices. Given the analysis of the ALI of the practices, the results reveal that rotational cropping (ALI = 218), planting of cover crops (ALI = 218) and efficient manure management (ALI = 218) had a high level of social acceptance among the sampled farmers in Mthonjaneni, while agroforestry (ALI = 371), cultivation of cover crops (ALI = 381) and diet improvement for animals (ALI = 378) had a high level of social acceptance among those in uMhlathuze. Results from the combined analysis show a similar result obtained for uMhlathuze where agroforestry (ALI = 559), cultivation of cover crops (ALI = 574) and diet improvement for animals (ALI = 554) had a high level of social acceptance among the sampled farmers in the district.

The farmers in Mthonjaneni had low social acceptance for the use of wetlands (ALI = 194), soil conservation (ALI = 188) and diet improvement for animals (ALI = 196) while those in uMhlathuze had a low social acceptance for conservation agriculture (ALI = 320), use of

wetland (ALI = 318) and cultivation of drought and heat tolerant crops (ALI = 314). Results from the combined analysis show that conservation agriculture (ALI = 497), use of wetlands (ALI = 491), cultivation of drought and heat tolerant crops (ALI = 495) and soil conservation (ALI = 500) had low social acceptance among the sampled farmers in KCDM. The other identified CSA practices had a medium level of social acceptance among the sampled farmers. Table 6.1 summarizes the perception of the sampled farmers on the social compatibility of CSA practices.

Table 6. 1: Farmers' Perception on Social Compatibility of Climate-Smart Agricultural Practices

Climate- Smart Agricultural Practice	Level of Social Acceptance														
	Mthonjaneni					uMhlathuze					Combined Analysis (KCDM)				
	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA
Conservation Agriculture	77 (70.6)	23 (21.1)	9 (8.3)	200	Medium	135 (61.9)	50 (22.9)	33 (15.1)	320	Low	212 (64.8)	73 (22.3)	42 (12.8)	497	Low
Agroforestry	85 (78.0)	18 (16.6)	6 (5.5)	206	Medium	171 (78.5)	29 (13.3)	18 (8.3)	371	High	256 (78.3)	47 (14.4)	24 (7.3)	559	High
Use of Organic Manure	81 (74.3)	26 (23.9)	2 (1.8)	214	Medium	134 (61.4)	66 (30.3)	18 (8.3)	334	Medium	215 (65.8)	92 (28.1)	20 (6.1)	522	Medium
Crop Rotation	80 (73.4)	29 (26.6)	0 (0.0)	218	High	141 (64.7)	61 (28.0)	16 (7.3)	343	Medium	221 (67.6)	90 (27.5)	16 (4.9)	532	Medium
Crop Diversification	79 (72.5)	25 (22.9)	5 (4.6)	208	Medium	137 (62.8)	53 (24.3)	28 (12.8)	327	Medium	216 (66.1)	78 (23.9)	33 (10.1)	510	Medium
Mulching	87 (79.8)	15 (13.8)	7 (6.4)	204	Medium	153 (70.2)	48 (22.0)	17 (7.8)	354	Medium	240 (73.4)	63 (19.3)	24 (7.3)	543	Medium
Use of Wetland	76 (69.7)	21 (19.3)	12 (11.0)	194	Low	136 (62.4)	46 (21.2)	36 (16.5)	318	Low	212 (64.8)	67 (20.5)	48 (14.7)	491	Low
Planting of Drought and Heat Tolerant Crops	75 (68.8)	31 (28.4)	3 (2.8)	212	Medium	128 (58.7)	58 (26.6)	32 (14.7)	314	Low	203 (62.1)	89 (27.2)	35 (10.7)	495	Low
Planting of Cover Crops	84 (77.1)	25 (22.9)	0 (0.0)	218	High	163 (74.7)	55 (25.2)	0 (0.0)	381	High	247 (75.5)	80 (24.5)	0 (0.0)	574	High
Soil Conservation	74 (67.9)	20 (18.3)	15 (13.8)	188	Low	147 (67.4)	38 (17.4)	33 (15.1)	332	Medium	221 (67.6)	58 (17.7)	48 (14.7)	500	Low
Integrated Crop-Livestock Management	77 (70.6)	31 (28.4)	1 (0.9)	216	Medium	148 (67.9)	43 (19.7)	27 (12.4)	339	Medium	225 (68.8)	74 (22.6)	28 (8.6)	524	Medium
Improved Grazing	75 (68.8)	25 (22.9)	9 (8.3)	200	Medium	140 (64.2)	67 (30.7)	11 (5.0)	347	Medium	215 (65.8)	92 (28.1)	20 (6.1)	522	Medium
Efficient Manure Management	78 (71.5)	31 (28.4)	0 (0.0)	218	High	141 (64.7)	61 (28.0)	16 (7.3)	343	Medium	219 (67.0)	92 (28.1)	16 (4.9)	530	Medium
Diet Improvement for Animals	78 (71.5)	20 (18.3)	11 (10.1)	196	Low	162 (74.3)	54 (24.8)	2 (0.9)	378	High	240 (73.4)	74 (22.6)	13 (4.0)	554	High

A; N; NA; ALI & CA denote Acceptable; Neutral; Not Acceptable; Acceptance Level Index & Category of Acceptance

Source: Survey Data (2018/19)

### 6.3.2 Farmers' Perception of Technical Compatibility of CSA Practices

Table 6.2 shows the level of the sampled farmers' acceptance of the identified CSA practices based on the ease of adoption or use. The use of organic manure (ALI = 179), rotational cropping (ALI = 179), crop diversification (ALI = 175) and mulching (ALI = 174) had a high level of acceptance among farmers in Mthonjaneni while the use of organic manure (ALI = 366), rotational cropping (ALI = 350), mulching (ALI = 351) and cultivation of cover crops (ALI = 364) had a high level of acceptance among those in uMhlathuze. Results from the combined analysis show that the use of organic manure (ALI = 545), crop rotation (ALI = 529), mulching (ALI = 525) and cultivation of cover crops (ALI = 533) had a high level of acceptance among the sampled farmers in KCDM.

The sampled farmers in Mthonjaneni showed a low level of acceptance for conservation agriculture (ALI = 139), agroforestry (ALI = 139), soil conservation (ALI = 139) and diet improvement for animals (ALI = 136) based on technicality, while their counterparts in uMhlathuze had a low level of acceptance for conservation agriculture (ALI = 293), agroforestry (ALI = 291), cultivation of drought and heat tolerant crops (ALI = 292) and soil conservation (ALI = 284). Results from the combined analysis show that farmers in KCDM had a low level of acceptance for conservation agriculture (ALI = 432), agroforestry (ALI = 430), cultivation of drought and heat-tolerant crop (ALI = 434) and soil conservation (ALI = 423). Table 6.2 summarizes these perceptions.

Table 6. 2: Farmers' Perception of Technical Compatibility of Climate-Smart Agricultural Practices

Climate- Smart Agricultural Practice	Level of Acceptance based on Technicality														
	Mthonjaneni					uMhlathuze					Combined Analysis (KCDM)				
	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA
Conservation Agriculture	60 (55.1)	19 (17.4)	30 (27.5)	139	Low	120 (55.1)	53 (24.3)	45 (20.6)	293	Low	180 (55.1)	72 (22.0)	75 (23.0)	432	Low
Agroforestry	65 (59.6)	9 (8.3)	35 (32.1)	139	Low	133 (61.0)	25 (11.5)	60 (27.5)	291	Low	198 (60.6)	34 (10.4)	95 (29.1)	430	Low
Use of Organic Manure	85 (75.2)	9 (8.3)	15 (13.8)	179	High	168 (77.1)	30 (13.8)	20 (9.2)	366	High	253 (77.4)	39 (11.9)	35 (10.7)	545	High
Crop Rotation	82 (75.2)	15 (13.8)	12 (11.0)	179	High	155 (71.1)	40 (18.4)	23 (10.6)	350	High	237 (72.5)	55 (16.8)	35 (10.7)	529	High
Crop Diversification	76 (69.7)	23 (21.1)	10 (9.2)	175	High	141 (64.7)	49 (22.5)	28 (12.8)	331	Medium	217 (66.4)	72 (22.0)	38 (11.6)	506	Medium
Mulching	83 (76.2)	8 (7.3)	18 (16.5)	174	High	158 (72.5)	35 (16.1)	25 (11.5)	351	High	241 (73.7)	43 (13.2)	43 (13.2)	525	High
Use of Wetland	70 (64.2)	17 (15.6)	22 (20.2)	157	Medium	132 (60.6)	46 (21.1)	40 (18.4)	310	Medium	202 (61.8)	63 (19.3)	62 (19.0)	467	Medium
Planting of Drought and Heat Tolerant Crops	68 (62.4)	6 (5.5)	35 (32.1)	142	Medium	130 (59.6)	32 (14.7)	56 (25.7)	292	Low	198 (60.6)	38 (11.6)	91 (27.8)	434	Low
Planting of Cover Crops	80 (73.4)	9 (8.3)	20 (18.4)	169	Medium	172 (78.9)	20 (9.2)	26 (11.9)	364	High	252 (77.1)	29 (8.9)	46 (14.1)	533	High
Soil Conservation	67 (61.5)	5 (4.6)	37 (33.9)	139	Low	129 (59.2)	26 (11.9)	63 (28.9)	284	Low	196 (59.9)	31 (9.5)	100(30.6)	423	Low
Integrated Crop-Livestock Management	73 (67.0)	11 (10.1)	25 (22.9)	157	Medium	150 (68.8)	23 (10.6)	45 (20.6)	323	Medium	223 (68.2)	34 (10.4)	70 (21.4)	480	Medium
Improved Grazing	77 (70.6)	2 (1.8)	30 (27.5)	156	Medium	146 (67.0)	39 (17.9)	33 (15.1)	331	Medium	223 (68.2)	41 (12.6)	63 (19.3)	487	Medium
Efficient Manure Management	67 (61.5)	6 (5.5)	36 (33.0)	140	Medium	141 (64.7)	42 (19.3)	35 (16.1)	324	Medium	208 (63.6)	48 (14.7)	71 (21.7)	464	Medium
Diet Improvement for Animals	65 (59.6)	6 (5.5)	38 (34.9)	136	Low	138 (63.3)	31 (14.2)	49 (22.5)	307	Medium	203 (62.1)	37 (11.3)	87 (26.6)	443	Medium

A; N; NA; ALI & CA denote Acceptable; Neutral; Not Acceptable; Acceptance Level Index & Category of Acceptance

Source: Survey Data (2018/19)

### **6.3.3 Farmers' Perception of Economic Compatibility of CSA Practices**

Table 6.3 shows the level of the farmers' acceptance of the identified CSA practices in terms of the economics of the use of the practices. Rotational cropping (ALI = 180) and mulching (ALI = 178) were perceived as economical by the farmers in Mthonjaneni while those in uMhlathuze Municipality found the use of organic manure (ALI = 361), mulching and cultivation of cover crops (ALI = 351) economical. The combined analysis reveals that the use of organic manure (ALI = 542), rotational cropping (ALI = 515) and mulching (ALI = 541) had a high level of acceptance among the sampled farmers in KCDM in terms of economic compatibility.

The farmers in Mthonjaneni had a low level of acceptance for the cultivation of drought and heat tolerant crops (ALI = 135) and diet improvement for animals (ALI = 135), while their counterparts in uMhlathuze had a low level of acceptance for agroforestry (ALI = 235) and cultivation of drought and heat tolerant crops (ALI = 247). The combined analysis shows that the sampled farmers in KCDM had a low level of acceptance for agroforestry (ALI = 436) and cultivation of drought and heat tolerant crops (ALI = 430). Table 6.3 summarizes the perceptions of economic compatibility of CSA practices held by the farmers.

Table 6. 3: Farmers' Perception of Economic Compatibility of Climate-Smart Agricultural Practices

Climate- Smart Agricultural Practice	Level of Acceptance based on Economics of Use														
	Mthonjaneni					uMhlathuze					Combined Analysis (KCDM)				
	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA
Conservation Agriculture	70 (64.2)	14 (12.8)	25 (22.9)	154	Medium	130 (59.6)	18 (8.3)	70 (32.1)	278	Medium	200 (61.2)	84 (25.7)	95 (29.1)	484	Medium
Agroforestry	60 (55.1)	27 (24.8)	22 (20.2)	147	Medium	102 (46.8)	31 (14.2)	85 (39.0)	235	Low	162 (49.5)	112 (34.3)	107 (32.7)	436	Low
Use of Organic Manure	75 (68.8)	16 (14.7)	18 (16.5)	166	Medium	173 (79.4)	15 (6.9)	30 (13.8)	361	High	248 (75.8)	46 (14.1)	48 (14.7)	542	High
Crop Rotation	83 (76.2)	14 (12.8)	12 (11.0)	180	High	151 (69.3)	34 (15.6)	33 (15.1)	336	Medium	234 (71.6)	47 (14.4)	45 (13.8)	515	High
Crop Diversification	72 (66.1)	17 (15.6)	20 (18.4)	161	Medium	134 (61.5)	48 (22.0)	36 (16.5)	316	Medium	206 (63.0)	53 (16.2)	56 (17.1)	465	Medium
Mulching	80 (73.4)	18 (16.5)	11 (10.1)	178	High	168 (77.1)	23 (10.6)	27 (12.4)	359	High	248 (75.8)	45 (13.8)	38 (11.6)	541	High
Use of Wetland	65 (59.6)	16 (14.7)	28 (25.7)	146	Medium	121 (55.5)	29 (13.3)	68 (31.2)	271	Medium	186 (56.9)	84 (25.7)	96 (29.4)	456	Medium
Planting of Drought and Heat Tolerant Crops	62 (56.9)	11 (10.1)	36 (33.0)	135	Low	108 (49.5)	31 (14.2)	79 (36.2)	247	Low	170 (52.0)	90 (27.5)	115 (35.2)	430	Low
Planting of Cover Crops	68 (62.4)	16 (14.7)	25 (22.9)	152	Medium	156 (71.6)	39 (17.9)	23 (10.6)	351	High	224 (68.5)	39 (11.9)	48 (14.7)	487	Medium
Soil Conservation	65 (59.6)	11 (10.1)	33 (30.3)	141	Medium	125 (57.3)	28 (12.8)	65 (29.8)	278	Medium	190 (58.1)	76 (23.2)	98 (30.0)	456	Medium
Integrated Crop-Livestock Management	65 (59.6)	17 (15.6)	27 (24.8)	147	Medium	146 (67.0)	24 (11.0)	48 (22.0)	316	Medium	211 (64.5)	65 (19.9)	75 (22.9)	487	Medium
Improved Grazing	77 (70.6)	12 (11.0)	20 (18.4)	166	Medium	144 (66.1)	36 (16.5)	38 (17.4)	324	Medium	221 (67.6)	50 (15.3)	58 (17.7)	492	Medium
Efficient Manure Management	65 (59.6)	16 (14.7)	28 (25.7)	146	Medium	138 (63.3)	47 (21.6)	33 (15.1)	323	Medium	203 (62.1)	49 (15.0)	61 (18.7)	455	Medium
Diet Improvement for Animals	62 (56.9)	11 (10.1)	36 (33.0)	135	Low	129 (59.2)	35 (16.1)	54 (24.8)	293	Medium	191 (58.4)	65 (19.9)	90 (27.5)	447	Medium

A; N; NA; ALI & CA denote Acceptable; Neutral; Not Acceptable; Acceptance Level Index & Category of Acceptance

Source: Survey Data (2018/19)

#### **6.3.4 Farmers' Perception of the Environmental Compatibility of CSA Practices**

Table 6.4 shows the level of the sampled farmers' acceptance of the identified CSA practices in terms of the environmental friendliness of the practices. Farmers in Mthonjaneni Municipality had a high level of acceptance for agroforestry (ALI = 178) and rotational cropping (ALI = 175) while it was the use of organic manure (ALI = 358) that was highly accepted by the sampled farmers in uMhlathuze. The combined analysis reveals that the use of organic manure (ALI = 524) was highly accepted by the sampled farmers in KCDM in terms of environmental friendliness of the identified practices. The remaining recognized CSA practices had a medium level of acceptance among the sampled farmers.

The sampled farmers in Mthonjaneni Municipality had a relatively low level of acceptance for the use of wetlands (ALI = 159), cultivation of drought-tolerant crops (ALI = 158), efficient manure management (ALI = 158) and diet improvement for animals (ALI = 158) as environmentally friendly. However, those in uMhlathuze had a relatively low level of acceptance for crop diversification (ALI = 296) and the use of wetlands (ALI = 286). The combined analysis shows that the use of wetland (ALI = 445) and efficient manure management (ALI = 436) had low acceptance from the sampled farmers in KCDM. Table 6.4 summarizes these perceptions.

Table 6. 4: Farmers' Perception of Environmental Compatibility of Climate-Smart Agricultural Practices

Climate- Smart Agricultural Practice	Level of Acceptance based on Environmental Friendliness														
	Mthonjaneni					uMhlathuze					Combined Analysis (KCDM)				
	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA	A No (%)	N No (%)	NA No (%)	ALI	CA
Conservation Agriculture	70 (64.2)	28 (25.7)	11 (10.1)	168	Medium	135 (61.9)	60 (27.5)	23 (10.6)	330	Medium	205 (62.7)	88 (26.9)	34 (10.4)	498	Medium
Agroforestry	80 (73.4)	18 (16.5)	11 (10.1)	178	High	128 (58.7)	55 (25.2)	35 (16.1)	311	Medium	208 (63.6)	73 (22.3)	46 (14.1)	489	Medium
Use of Organic Manure	73 (67.0)	20 (18.3)	16 (14.7)	166	Medium	160 (73.4)	38 (17.4)	20 (9.2)	358	High	233 (71.3)	58 (17.7)	36 (11.0)	524	High
Crop Rotation	75 (68.8)	25 (22.9)	9 (8.3)	175	High	146 (67.0)	37 (17.0)	35 (16.1)	329	Medium	221 (67.6)	62 (19.0)	44 (13.5)	504	Medium
Crop Diversification	68 (62.4)	30 (27.5)	11 (10.1)	166	Medium	128 (58.7)	40 (18.4)	50 (22.9)	296	Low	196 (59.9)	70 (21.4)	61 (18.6)	462	Medium
Mulching	67 (61.5)	32 (29.4)	10 (9.2)	166	Medium	140 (64.2)	30 (13.8)	48 (22.0)	310	Medium	207 (63.3)	62 (19.0)	58 (17.7)	476	Medium
Use of Wetland	62 (56.9)	35 (32.1)	12 (11.0)	159	Low	113 (51.8)	60 (27.5)	45 (20.6)	286	Low	175 (53.5)	95 (29.1)	57 (17.7)	445	Low
Planting of Drought and Heat Tolerant Crops	60 (55.1)	38 (34.9)	11 (10.1)	158	Low	135 (61.9)	66 (30.3)	17 (7.8)	336	Medium	195 (59.6)	104 (31.8)	28 (8.6)	494	Medium
Planting of Cover Crops	70 (64.2)	27 (24.8)	12 (11.0)	167	Medium	143 (65.6)	25 (11.5)	50 (22.9)	311	Medium	213 (65.1)	52 (15.9)	62 (19.0)	478	Medium
Soil Conservation	66 (60.6)	33 (30.3)	10 (9.2)	165	Medium	138 (63.3)	62 (28.4)	18 (8.3)	338	Medium	204 (62.4)	95 (29.1)	28 (8.6)	503	Medium
Integrated Crop-Livestock Management	65 (59.6)	35 (32.1)	9 (11.0)	165	Medium	140 (64.2)	50 (22.9)	28 (12.8)	328	Medium	205 (62.7)	85 (26.0)	37 (11.3)	495	Medium
Improved Grazing	65 (59.6)	32 (29.4)	12 (11.0)	162	Medium	135 (61.9)	40 (18.4)	43 (19.7)	320	Medium	200 (61.2)	72 (22.0)	55 (16.8)	472	Medium
Efficient Manure Management	60 (55.1)	38 (34.9)	11 (10.1)	158	Low	120 (55.1)	38 (17.4)	60 (27.5)	320	Medium	180 (55.1)	76 (23.2)	71 (21.7)	436	Low
Diet Improvement for Animals	61 (56.0)	36 (33.0)	12 (11.0)	158	Low	136 (62.4)	46 (21.1)	36 (16.5)	330	Medium	197 (60.2)	82 (25.1)	48 (14.7)	476	Medium

A; N; NA; ALI & CA denote Acceptable; Neutral; Not Acceptable; Acceptance Level Index & Category of Acceptance

Source: Survey Data (2018/19)

## 6.4 Discussion

In terms of social compatibility, eleven out of the fourteen practices had either a high or medium level of acceptance by the sampled farmers. The planting of cover crops was highly embraced by the sampled farmers in both municipalities meaning that the cultivation of cover crops had no conflict with their cultural values and neither do they consider it as gender-specific. The planting of cover crops is indeed a common practice in KZN to protect and augment the fertility of the soil. Cover crops such as oats, vetch and triticale are planted as winter cover in maize farms while sorghum (to a lesser degree) is planted as summer cover (Strachan, 2014).

The high level of acceptance for rotational cropping by the Mthonjaneni farmers also confirms the assertion of Findlay and Manson (2011) that crops such as cowpea, dry beans and soybeans are often used in rotation with other crops and are intercropped with maize by farmers in KZN. The responses of the farmers further reveal that the efficient management of manure conformed very well with their cultural values, and therefore, they showed a high level of acceptance for it. Those in uMhlathuze were highly accepting of agroforestry and diet improvement for animals in addition to the planting of cover crops implying that these practices are not in conflict with their cultural values and neither do they consider them to be gender-specific. The combined analysis reveals that agroforestry, planting of cover crops and diet improvement for animals were highly accepted by the sampled farmers in KCDM. This suggests that mainstreaming the cultivation of cover crops, rotational cropping, agroforestry, in CSA projects for crop farmers and practices such as efficient manure management and diet improvement for animals for livestock farmers are not culturally or socially repugnant in the study area/ s.

The use of wetlands had a low level of acceptance among the sampled farmers in both municipalities suggesting that some of them consider it to be in conflict with their social or cultural values. The farmers in Mthonjaneni also had a low level of acceptance for soil conservation and diet improvement for animals while their counterparts in uMhlathuze had a low level of acceptance for conservation agriculture and planting of drought and heat tolerant crops in addition to the use of wetlands. The finding suggests that careful consideration of the disposition and reaction of farmers to embracing the use of wetland, soil conservation and planting of drought and heat tolerant crops is quite needful for adoption in CSA programs.

With respect to technical compatibility, the farmers in both municipalities considered the use of organic manure, rotational cropping and mulching to be easy to practice. This implies that these practices will not be difficult for the farmers in the study area/ s. Besides, farmers in Mthonjaneni found it relatively easier to diversify their crop production while those in uMhlathuze found planting of cover crops easy. The combined analysis reveals that farmers in KCDM found it easy to use organic manure, rotational cropping, mulching and planting of cover crops. The high level of acceptance for these practices could be attributed to the topography and climatic condition of the study area/ s (Gbetibouo *et al.*, 2010; KZN Top Business, 2017).

Conservation agriculture, agroforestry and soil conservation had low acceptance levels in both municipalities. The farmers perceived the CSA practices to be relatively challenging to adopt and practice. This could be because conservation agriculture, agroforestry and soil conservation require some technical capacity and consistency that small-scale farmers find difficult. The farmers in Mthonjaneni had a low level of acceptance for diet improvement for animals in addition to the aforementioned practices. This was also the case for the planting of drought and heat tolerant crops among their counterparts in uMhlathuze. At the combined analysis level, results reveal a low level of acceptance for conservation agriculture, agroforestry, planting of drought and heat tolerant crops and soil conservation by the sampled farmers in KCDM. These findings imply that small-scale farmers need a lot of support and technical assistance for the successful mainstreaming of conservation agriculture, agroforestry and soil conservation in the small-scale farming system.

The farmers in Mthonjaneni had a high level of acceptance for crop rotation and mulching with the reason that these were cheap to adopt. Their counterparts in uMhlathuze highly embraced the use of organic manure and mulching based for the same reason. The combined analysis shows that the sampled farmers in KCDM highly embraced the use of organic manure, crop rotation and mulching due to their cheap cost. CSA practices that are not expensive to adopt and practice are adequate for small-scale.

The Mthonjaneni farmers considered the planting of drought and heat tolerant crops and diet improvement for animals to be expensive to adopt and sustain, and therefore had a low level of acceptance for them. Their counterparts in uMhlathuze had the same disposition towards agroforestry and planting of drought and heat tolerant crops. The combined analysis reveals that the sampled farmers in KCDM had low acceptance for agroforestry and planting of drought

and heat tolerant crops with the reason that they are expensive to adopt and sustain. Small-scale farmers will need a lot of assurance and financial assistance to adopt expensive CSA practices. This agrees with the opinion of Mwongera *et al.* (2017) that farmers will have more interest in the immediate benefits (maximize yield and profit) they can enjoy than in any long-term technical schemes.

The farmers in Mthonjaneni highly embraced agroforestry and rotational cropping for the reason that these practices are environmentally friendly while their counterparts in uMhlatuze highly embraced the use of organic manure. The combined analysis reveals that the sampled farmers in KCDM highly accepted the use of organic manure. The use of wetland, planting of drought and heat tolerant crops, efficient manure management and diet improvement for animals had low acceptance among farmers in Mthonjaneni. Their counterparts in uMhlatuze had low approval for crop diversification and the use of wetlands while the combined analysis reveals that the use of wetland and efficient manure management had low acceptance among the farmers in KCDM. These findings show that there is the need to consider the preconceptions of farmers on CSA practices and to re-orient them if need be.

## **6.5 Conclusion and policy implications**

This study provides insights into the applicability of CSA practices with a focus on how farmers perceive the social, technical, economic and environmental compatibility of the practices. Past studies focus on the characteristics of farmers while conducting research on the adoption of agricultural technologies. However, the focus on farmers' characteristics has not been holistic in addressing the determinants of adoption. This is reflected in the variations still observed in adoption, which are only revealed in the exogenous factors not captured by models used in past studies. This study, therefore, deviates from that conventional approach by focusing on the features of the CSA practices themselves. The findings reveal how the farmers' perceptions of the CSA practices can affect their disposition towards the acceptance of the practices.

Based on the findings, it is argued that farmers' preferences for, and willingness to adopt CSA practices or technologies are significantly different based on the potential benefits and cost of the practices or technologies. This study further argues that farmers may not have enough willingness to adopt many CSA technologies even with their potential benefits. In view of this, policies and programs aimed at mainstreaming CSA practices or technologies should pay adequate attention to site-specific factors. Furthermore, policy designs and implementations should emphasize the critical role of the provision of information on the available CSA

technologies or practices. Financial plans and resources should also be integrated into the CSA policy framework to assist farmers in the adoption of technologies that are suitable for their location. Finally, this study recommends that researchers conduct further empirical studies on the characteristics of CSA practices and how they influence CSA adoption. Similar studies can be done in other areas of South Africa to enhance the reliability of the findings. Further studies can also be conducted on the role of institutional mechanisms and resource tenure in CSA mainstreaming and adoption.

### **Author Contributions**

V.O.A. conceived and designed the study. V.O.A collected and analyzed the data for the study and drafted the manuscript. M.S. and A.O. supervised the study. M.S and A.O scrutinized and verified the research process, methods and the manuscript. All authors contributed to the outcome of the manuscript.

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### **Conflict of interest**

The authors declare no conflict of interest.

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## CHAPTER SEVEN<sup>4</sup>

### THE EFFECT OF CLIMATE-SMART AGRICULTURE ADOPTION ON THE PRODUCTIVITY OF SMALL-SCALE FARMING SYSTEMS: EVIDENCE FROM FARMING HOUSEHOLDS IN KING CETSHWAYO DISTRICT MUNICIPALITY

#### Abstract

Low resource availability and output in the small-scale farming system, complicated by climate change and variability, constitute a major challenge associated with poor agricultural performance in many developing countries. This paper examines the effect of the adoption of CSA practices on the productivity of small-scale farming households in KCDM in the KZN province of South Africa. A multi-stage sampling technique was used for sample selection. Data were generated with the aid of a structured questionnaire from 327 small-scale farmers from two local municipalities (Mthonjaneni and uMhlathuze) in the district based on their agricultural potentials. Composite score, OLS regression model and descriptive statistics were used for data analysis. The results show that CSA adoption had a positive significant effect on Mthonjaneni, uMhlathuze and the combined analysis (KCDM) at 1 per cent ( $p = 0.000$ ), 5 per cent ( $p = 0.025$ ) and 1 per cent ( $p = 0.000$ ) respectively. The OLS regression model predicts that the adoption of an additional CSA practice would increase the TVP of farmers by about ZAR 309, ZAR 212 and ZAR 199 in Mthonjaneni, uMhlathuze and KCDM respectively. Age, gender, marital status, household size, years of farming experience, contact with extension officers, livestock farming, mixed farming and membership of an agricultural-related group or association were also found to have a positive significant effect on TVP, while off-farm income had a negative significant effect on TVP. This paper argues that efforts such as intensified extension services and creation of structures that will improve farmers' exposure to essential information are needed to encourage CSA adoption among small-scale farmers to enhance improvement in farmers' productivity.

**Keywords:** Adoption, climate-smart agriculture, households, productivity, small-scale farmers

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<sup>4</sup> N/B This chapter is prepared as an article for submission to an accredited journal.

\* Text that has already been explained in the methodology chapter will be skipped, with only reference given to.

## 7.1 Introduction

Agricultural economists define agricultural productivity in terms of output per unit of input or output per unit of land area (Obasi *et al.*, 2013; Ololade & Olagunju, 2013; Onogwu *et al.*, 2017). Improvement in agricultural productivity is considered to be the outcome of efficient use of the physical, socioeconomic, institutional and technological factors involved in agricultural production (Onogwu *et al.*, 2017). Low yields or output and the limited resources of small-scale farmers constitute part of the challenges associated with poor agricultural performance in many developing countries (Anyanwu, 2013). With about 80 per cent of all the farms in the region, small-scale agriculture accounts for the bulk of agricultural production in sub-Saharan Africa and about 175 million people, 70 per cent of whom are women (Harris & Consulting, 2014). Many of these small-scale farmers contend with diverse challenges which continue to hamper the potentials of the small-scale agricultural sector (Searchinger *et al.*, 2014). Many are resource-poor, cannot afford adequate inputs and labor and most practise low-input/ low-output subsistence agriculture (Harris & Consulting, 2014).

The adverse effects of climate change have complicated the pressure on small-scale farmers in the region in the production of sufficient food for its growing population. These effects are likely to lead to the increase in the number of undernourished people by about 132 million by the middle of the century (Searchinger *et al.*, 2014). Between 2006 and 2050, food production needs to grow by about 360 per cent to meet the food demand of the growing population (Searchinger *et al.*, 2014). With this challenge, the agricultural sector in Sub-Saharan Africa needs to be able to overcome the adverse impacts of climate change.

This need is further intensified by the depletion of natural resources (Headey, 2011). The FAO (2013) concept of CSA has the potential of sustainably increasing agricultural productivity as well as reducing climate change vulnerability and emissions that can cause climate change (Lipper *et al.* (2014). It is a concept that combines social and ecological resilience (Nwajiuba *et al.*, 2015). CSA-led increase in production should be driven by the integration of technologies, policies, financing mechanisms, risk management schemes and institutional developments (Nwajiuba *et al.*, 2015). In this regard, there is also the need for mainstreaming CSA through structured development programs, the transformation of food systems and farming systems as well as the use of practices adapted to specific communities. Against this background, this paper provides empirical investigation of the effects of the adoption of CSA

practices on the agricultural productivity of small-scale farmers in the study area/ s. In this paper, agricultural productivity is conceived as the TVP of the sampled farmers.

## **7.2 Materials and Methods**

### **7.2.1 Study Area**

As earlier stated in chapter four of this thesis, the research study was conducted in the KCDM of KZN province, South Africa. Refer to chapter three (section 3.2\*) for details on the description and selection of study area/ s.

### **7.2.2 Research Design**

A cross-sectional research design was adopted. Refer to chapter three (section 3.7\*) for detailed information on the description and rationale of the chosen design.

#### ***Conceptual framework***

In this paper, climate change is defined as observable variations in climatic conditions. Climate change affects the small-scale farming system directly by influencing pest and disease conditions within the system, the water holding capacity of the soil, the soil fertility and eventually the output. It influences the small-scale farming system indirectly by influencing agricultural demand, income distribution and economic growth. Climate change also impacts the environment, thereby influencing human activities. However, the adoption of CSA by small-scale farming households provides them with the triple-win benefits of food security, adaptation and mitigation. The adaptation and mitigation benefits are expected to lead to sustainable increase in farm productivity with the potential to enhance food security. When there is increase in agricultural productivity, it increases the capacity of the farming system to meet the increasing food demand, thereby enhancing food security. Climate-smart agriculture uptake does not only influence the food system but promises a positive impact on the environment through climate change mitigation. Figure 7.1 illustrates how this paper conceptualizes the influence of CSA adoption in the small-scale farming system on agricultural productivity.

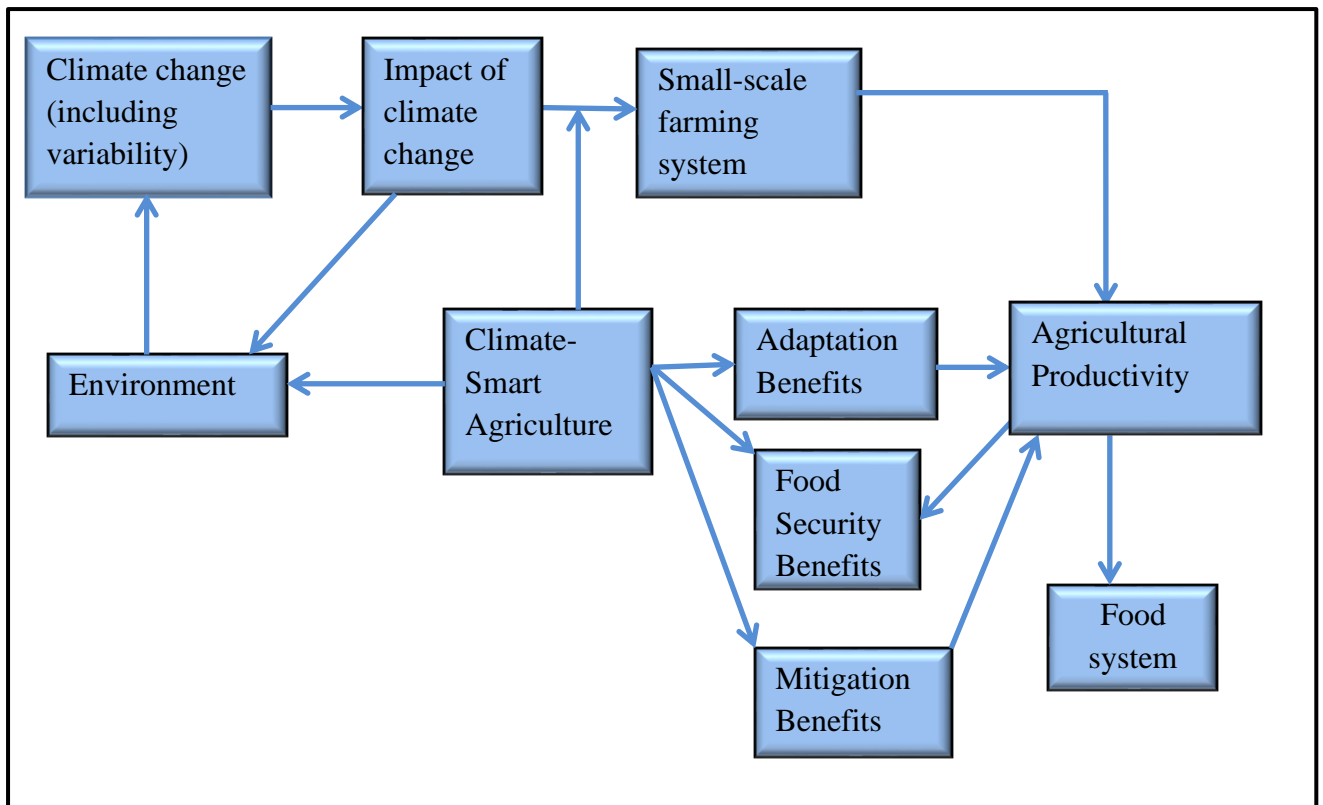


Figure 7. 1: Conceptual framework – Influence of CSA adoption on agricultural productivity  
Source: Author’s conceptual design

### 7.2.3 Sampling Technique and Data Collection

The sampling technique and procedure for data collection is the same as already described in chapter four. Refer to chapter three (section 3.8.1\*) for detailed information on the sample size calculation and data collection procedures.

### 7.2.4 Data Analysis

Following Obasi *et al.* (2013) and Onogwu *et al.* (2017), some variables were hypothesized as factors affecting agricultural productivity in this paper. The TVPs of the farmers were obtained from the multiple outputs of the farmers.

The TVP is calculated as the Rand worth of outputs produced by the different amounts of the inputs used (Varian, 2014).

$$\text{TVP} = \text{Total Physical Product} \times \text{Price of the outputs} \quad (14)$$

The effect of the adoption of CSA practices on the productivity of the small-scale farming households in the study area/ s was then examined using the OLS regression model.

The linear function for the OLS regression model is specified as follows:

$$Y = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \beta_8 Z_8 + \beta_9 Z_9 + \beta_{10} Z_{10} + \beta_{11} Z_{11} + \beta_{12} Z_{12} + \beta_{13} Z_{13} + \beta_{14} Z_{14} \quad (15)$$

Trailing the studies of Obasi *et al.* (2013) and Onogwu *et al.* (2017), some variables were hypothesized as factors affecting farm output. Table 7.1 summarizes the explanatory variables used in the OLS regression model and their *a priori* expectations.

Table 7. 1: Explanatory variables in the OLS regression model

Variable	Description and measurement type	Expected outcome (+/-)
Level of CSA adoption	Number of CSA practices used	+
Age	Age of respondent in years (continuous)	-
Educational status	Number of years spent by respondents in acquiring formal education (continuous)	+
Household size	Number of members in the household (continuous)	+
Average monthly off-farm income (ZAR)	Total monthly income from non-farm enterprise (continuous)	+/-
Farming experience	Number of years spent in farming (continuous)	+
The distance of farm to homestead	The distance of home to the farm location in kilometers (continuous)	-
Contact with extension agents	Number of yearly visits of extension agents (continuous)	+
Exposure to media	Number of mass media outfits accessed (continuous)	+
Gender	Respondents' gender (male =1; female = 0) (dummy)	+/-
Marital status	Marital status of respondents (single = 1; married = 2; divorced/separated = 3; widowed = 4)	+/-
Agricultural Production activity	Nature of farming activity (crop production = 1; livestock production = 2; both crop and livestock production = 3)	+/-
Membership to an agricultural-related group	Whether the respondent belongs to an agricultural-related group or association (yes = 1; otherwise = 0) (dummy)	+
Perception of the effect of climate change	Perception of respondent on the effect of climate change (significant adverse effect = 1; otherwise = 0) (dummy)	+

+/- Denote a positive or negative association to the dependent variable

Source: Author (2019)

The dependent variable  $Y_i = \text{TVP}$  of farmers, while the independent variables considered include the level of CSA adoption by farming households, respondents' age, educational status, household size, farm income, off-farm income, farming experience, distance of farm to homestead, contact with extension agents, exposure to media, gender, marital status, agricultural production activity, membership of agricultural-related group, and perception of the effect of climate change. The direction of the influence of level of CSA adoption on TVP is predetermined to be positive. Wekesa *et al.* (2018) noted that CSA adoption would improve agricultural productivity among small-scale farmers. Age is hypothesized to negatively influence TVP as ageing is associated with a decline in agility and increased risk averseness. Literacy is accompanied by increased level of exposure and is therefore hypothesized to have a positive effect on TVP (Ngema *et al.*, 2018).

Members of a household are potential labor force for farming activities (Ngema *et al.*, 2018). As a result, household size is predetermined to positively influence TVP. The influence of off-farm income could not be predetermined since engagement outside farming activities could reduce commitment to agricultural production and in turn reduce TVP. On the other hand, income from alternative sources could be used to boost agricultural production. Farming experience is hypothesized to positively influence TVP. The more the farming experience, the better the chances of exposure to improved agricultural techniques (Myeni *et al.*, 2019). The distance of farm to homestead is expected to negatively affect TVP as longer distance is associated with increased cost of transportation of farm inputs and labor (Teklewold *et al.*, 2013). Extension and advisory services would expose farmers to improve techniques of agricultural production (Onyeneke *et al.*, 2018). Contact with agricultural agents is expected to drive TVP in a positive direction.

Exposure to media is anticipated to influence TVP positively. Farmers could make use of information obtained from the media productively in their agricultural engagement. The effect of gender and marital status could not be predetermined. The effect of agricultural production activity on TVP could not be predetermined as well. Agricultural production activity engaged by the farming households was captured as crop production, livestock production, and both crop and livestock production. Membership of an agricultural related group could boost the social capital of farmers which could facilitate their access to resources (BIRTHAL *et al.*, 2015). Membership of an agricultural related groups is anticipated to affect TVP positively. Farmers who have knowledge of climate change and its effect would likely embrace measures that can

protect them from climate shocks. Perception of the impact of climate change is predetermined to positively drive TVP in a positive direction.

### ***Model Fitness of the Ordinary Least Square Regression Analysis***

According to Khine (2013), the goodness-of-fit of the model is a measure of the comparative quantity of the covariance and variances. The parameters with which the goodness-of-fit of the model for the study are measured include the R-Square statistics, F-statistic and the variance inflation factors (VIF) statistics. The R-Square statistic value for the regression model fitted for the responses from the farmers in Mthonjaneni, uMhlathuze and the combined analysis (Mthonjaneni and uMhlathuze) are 0.6703, 0.6365 and 0.6558 respectively. This implies that the independent variables captured in each of the model fitted explains about 67, 64 and 66 per cent of the total variability of the dependent variable of the models. The F-test shows the overall significance of the model (Montgomery, 2017), indicating that the F statistic is 4.70, 4.53 and 4.51 while the p-value associated with the F statistic are 0.000, 0.0027 and 0.000 respectively. The results imply that each of the models provides a very good fit (Refer to Table 7.2).

Variance inflation factors were used to test for any multicollinearity existing in the regression model. The VIF measures how much the variance is inflated. The rule of thumb for VIF is that any value above needs further interrogation, while values above 10 are indications of serious level of multicollinearity (Akinwande *et al.*, 2015). The VIF values for the parameters in each model indicate there is no problem with multicollinearity and the models are therefore deemed appropriate (Refer to Table 7.2). A Breusch-Pagan/Cook-Weisberg test for heteroscedasticity was also run for each of the models with the results showing that there is no problem of heteroscedasticity in any of the fitted model.

### **7.3 Results**

The descriptive results of the independent variables such as the socio-economic characteristics of the sampled farmers and the level of adoption of CSA captured by the composite score have already been presented in sections 5.3.1 and 5.3.2. The only descriptive results that will be presented in this chapter is the TVP of the farmers which is the dependent variable for the OLS regression model used.

### 7.3.1 Distribution of Respondents by the Total Value Product

Table 7.1 shows that the average TVP of the sampled farmers in Mthonjaneni was ZAR 12 963 with a range between ZAR 3 800 and ZAR 36 000, while the average TVP of their counterparts in uMhlathuze was ZAR 11 848 with a range between ZAR 3 100 and ZAR 32 500. The combined analysis shows an average of ZAR 12 219 for the sampled farmers in KCDM with their TVP ranging between ZAR 3 100 and ZAR 38 000.

Table 7. 2: Distribution of TVP among the sampled farmers (ZAR)

Measure of TVP	Mthonjaneni	uMhlathuze	Combined Analysis (KCDM)
Mean	12 962.6	11 847.6	12 219.1
Standard Deviation	9 527.6	6 959.5	7 877.1
Maximum	36 000.0	32 500.0	38 000.0
Minimum	3 800.0	3 100.0	3 100.0

Source: Survey Data (2018/19)

### 7.3.1 Effect of CSA adoption on the Agricultural Productivity of Respondents

Table 7.2 presents the empirical results of the OLS regression used in examining the effect of the levels of CSA adoption on the productivity of the sampled small-scale farmers in both Mthonjaneni and uMhlathuze municipalities. CSA adoption significantly affects the agricultural productivity of the sampled farmers in both municipalities. The level of CSA adoption of the sampled farmers was entered in the models as a continuous variable using the composite score (Section 5.3.2\*) generated from the number of practices adopted. Results show that CSA adoption positively correlates with the TVP of the sampled farmers in Mthonjaneni and uMhlathuze at 1 per cent ( $p = 0.000$ ) and 5 per cent ( $p = 0.025$ ) level of significance respectively. The model predicts that the adoption of an additional CSA practice will increase the TVP of the sampled farmers in Mthonjaneni by ZAR 309, while that of the farmers in uMhlathuze will be increased by ZAR 213. The combined analysis shows a positive correlation of the level of CSA adoption with TVP at 1 per cent level ( $p = 0.000$ ) of significance. The model predicts that the adoption of an additional CSA practice will increase the TVP of the sampled farmers by ZAR 199.

Table 7. 3: Effect of the level of CSA Adoption on the productivity of the sampled small-scale farmers

Variable	Mthonjaneni			uMhlathuze			Combined Analysis		
	Coefficient	P > / t /	VIF	Coefficient	P > / t /	VIF	Coefficient	P > / t /	VIF
Level of CSA Adoption	309.0566***	0.000	3.44	213.4329**	0.025	1.08	199.4114	0.000***	1.15
Age	-11.68491	0.358	2.26	-14.02216**	0.042	1.64	-10.66751	0.049**	1.73
Educational status	16.57399	0.515	1.23	1.323105	0.923	1.42	.7664268	0.943	1.29
Household size	50.89033**	0.041	1.79	51.62497***	0.004	1.44	56.58746	0.000***	1.46
Off-farm income	-.0531916**	0.033	1.46	.0231359	0.496	1.19	-.0088841	0.659	1.23
Farming experience	2.798826**	0.046	1.37	2.6943*	0.070	1.32	3.612021	0.046**	1.29
The distance of farm to homestead	55.71848	0.793	1.27	115.9787	0.476	1.26	107.3281	0.355	1.19
Contact with agricultural extension agents	6.259324**	0.054	1.33	7.211902*	0.064	1.15	10.10908	0.068*	1.16
Exposure to media	172.9991	0.129	1.23	117.5821*	0.079	1.11	128.9229	0.018**	1.09
Gender	351.5605*	0.089	1.58	60.28521	0.551	1.44	173.4448	0.050**	1.42
Marital Status (Base Category – Single)									
Married	139.9925*	0.068	3.69	145.3521*	0.085	2.47	214.9708	0.009***	2.63
Divorced/Separated	682.7874	0.458	1.19	275.2948	0.123	1.08	440.3675	0.170	1.10
Widowed	200.375	0.668	3.89	317.8154	0.260	2.21	332.3389	0.481	2.44
Agricultural Production Activity (Base Category – Crop Production)									
Livestock Production	-530.8985*	0.082	2.56	-82.33393	0.578	1.28	-30.18124	0.816	1.33
Both Crop and Livestock Production	633.9399**	0.023	1.85	112.492*	0.067	1.22	143.6337*	0.072	1.30
Membership to an agricultural-related association or group	202.12777**	0.039	1.17	-99.18068	0.388	1.10	200.8051	0.029**	1.09
Perception of the effect of climate change	193.1263	0.258	1.21	64.02807	0.577	1.15	90.7628	0.345	1.12
Constant	56.0481	0.916	-	1340.162	0.014	-	931.4539	0.017	-
Number of Observations		108		216		324			
F		4.70		4.53		4.51			
Prob > F		0.0000		0.0027		0.0000			
R-Squared		0.6703		0.6365		0.6558			
Adj R-Squared		0.6202		0.5889		0.6102			
Breusch-Pagan/Cook-Weisberg test for heteroscedasticity		Chi2(1) = 39.71 Prob > chi2 = 0.0000		Chi2(1) = 33.43 Prob > chi2 = 0.0000		Chi2(1) = 54.71 Prob > chi2 = 0.0000			

\*\*\*, \*\*, \* denotes statistical significance of 1%, 5% & 10 % level

Source: Survey Data (2018/19) computed from STATA 14

Farmers' age and exposure to the media were also entered into the regression model as continuous variables, with exposure to media captured as the number of mass media outfits accessed. Results show that age is statistically significant at 5 per cent level ( $p = 0.042$ ) and is negatively correlated with the TVP of the farmers in uMhlathuze. The model predicts that a year increase in the farmers' age in uMhlathuze would likely decrease their TVP by a value of ZAR 14. By contrast, the age of the sampled farmers has no significant effect on the TVP of the farmers in Mthonjaneni. The combined analysis shows a negative correlation of age of the farmers with their TVP at 5 per cent ( $p=0.049$ ) level of significance. The model predicts that a year increase in the age of the farmer would likely decrease their TVP by a worth of ZAR 10.

Household size was entered in the model as a continuous variable using the number of members of the household. Results show that household size positively correlates with the TVP of the sampled farmers in Mthonjaneni and uMhlathuze at 5 per cent ( $p = 0.041$ ) and 1 per cent ( $p = 0.004$ ) level of significance respectively. The model predicts that an additional member to the household is more likely to increase the TVP of the sampled farmers in each of the municipality by ZAR 51. The combined analysis also shows a positive correlation of household size with TVP at 1 per cent ( $p = 0.000$ ) level of significance. The model predicts that an additional member of the household will increase the TVP of the sampled farmers by ZAR 57.

Income from off-farm sources was also entered in the model as a continuous variable. Income from non-farm sources has a statistically significant effect at 5 per cent ( $p = 0.033$ ) but negatively correlated with the TVP of the sampled farmers in Mthonjaneni. The model predicts that a rand-increase in income from other sources than farming activities would likely decrease the TVP of the sampled farmers by a worth of ZAR 0.1. In contrast, income from non-farm sources has no significant effect on the TVP of the sampled farmers in uMhlathuze. Results from the combined analysis show that income from non-farm sources has no significant effect on the TVP of the sampled farmers in KCDM.

Farming experience was entered into the regression model as a continuous variable with years of farming experience captured as the number of years already spent farming. Results show that the years of farming experience positively correlates with the TVP of farmers in Mthonjaneni and uMhlathuze at 5 per cent ( $p = 0.046$ ) and 10 per cent ( $p = 0.070$ ) level of significance, respectively. The model predicts that a year increase in farming experience will likely increase the TVP of the sampled farmers in both municipalities by ZAR 3. The combined analysis shows positive correlation of years of farming experience with TVP at 5 per cent ( $p =$

0.046) level of significance. The model predicts that a year increase in farming experience will likely increase the TVP of farmers in both municipalities by ZAR 4.

Contact with extension officers was entered into the regression model as continuous variables as the number of yearly visits by extension officers to the sampled farmers. Contact with extension officers correlates with the TVP of farmers in Mthonjaneni and uMhlathuze at 5 per cent ( $p = 0.054$ ) and 10 per cent ( $p = 0.064$ ) level of significance respectively. The prediction of the model shows that additional contact with an extension worker would likely increase the TVP of the sampled farmers in Mthonjaneni by ZAR 6 and those in uMhlathuze by ZAR 7. Results from the combined analysis show a positive correlation of contact with extension officers with TVP at 10 per cent ( $p = 0.068$ ) level of significance. The prediction of the combined analysis is that additional contact with an extension worker would likely increase the TVP of the sampled farmers by ZAR 10 in KCDM.

Exposure to the media was captured in the regression model by the number of media sources the sampled farmers had access to from a list including newspapers, radio, television and the internet. Exposure to the media is statistically significant at 10 per cent level ( $p = 0.079$ ) and is positively correlated with the TVP of the sampled farmers in uMhlathuze. The prediction of the model is that an improvement in access to the mass media would likely increase the TVP of the sampled farmers in uMhlathuze by a worth of ZAR 118. By contrast, exposure to the media has no significant effect on the TVP of the farmers in Mthonjaneni. The combined analysis shows a positive correlation of exposure to the media with TVP at 5 per cent ( $p = 0.018$ ) level of significance. The prediction of the model is that access to an additional mass media outfit would likely increase the TVP of the sampled farmers by a worth of ZAR 129.

Gender was found to be statistically significant at 10 per cent level ( $p = 0.089$ ) and positively correlated with the TVP of the sampled farmers in Mthonjaneni. The prediction is that the TVP of a male farmer in Mthonjaneni would possibly increase by ZAR 352 compared to their female counterparts. By contrast, gender has no significant effect on the TVP of the sampled farmers in uMhlathuze. Results from the combined analysis show a positive correlation of gender with TVP at 5 per cent ( $p = 0.050$ ) level of significance. The model predicts that the male farmers are likely to realize a higher TVP compared to their female counterparts.

Marital status was entered into the model as a categorical variable consisting of four groups (single, married, divorced/separated and widowed) with the single group as the reference or base category. Results show that out of all the four groups, only one group describes a

significant relationship with productivity. The 'married' status has a positive statistical significance at 10 per cent ( $p = 0.068$ ) and 1 per cent ( $p = 0.085$ ) level on the TVP of the farmers in Mthonjaneni and uMhlathuze respectively. The model predicts that the sampled married farmers in Mthonjaneni are likely to have a higher TVP by about ZAR 140 than the farmers that are single, while the married farmers in uMhlathuze will have a higher TVP by ZAR 145 than the single farmers. Results from the combined analysis also show that 'married' status has a positive statistical significance of 1 per cent ( $p = 0.009$ ). The model predicts that the married farmers are likely to have their TVP increased by about ZAR 214 than their counterparts who are single.

The nature of agricultural production activity was entered into the model as a categorical variable consisting of three groups with the construct 'crop production' as the reference or base category. Results show that the remaining two groups describe a significant relationship with productivity. The 'livestock production' category in Mthonjaneni is statistically significant at 10 per cent level ( $p = 0.083$ ) and negatively correlated with TVP of the farmers, while it is not significant among those in uMhlathuze. The model predicts that the sampled farmers in Mthonjaneni who are solely into crop production are likely to have a higher TVP than their counterparts who are exclusively into livestock production by about ZAR 531. The 'crop and livestock production' category has a positive statistical significance of 5 per cent ( $p = 0.023$ ) and 10 per cent ( $0.067$ ) on the TVP of the sampled farmers in Mthonjaneni and uMhlathuze respectively. The model predicts that the farmers who integrated crop and livestock production in Mthonjaneni are likely to have a higher TVP than their counterparts who are solely into crop production by about ZAR 634. However, those integrating crop and livestock production in uMhlathuze are likely to have a higher TVP than those involved in crop production activity by about ZAR 113. The combined analysis shows that the 'crop and livestock production' category has a positive statistical significance of 10 per cent ( $p = 0.072$ ) on the TVP of the sampled farmers in KCDM. The model predicts that the farmers who integrated crop and livestock production are likely to have a higher TVP than their counterparts who are solely into crop production by about ZAR 144.

Membership of agricultural-related groups was entered into the regression model as a dummy variable with responses indicated by yes or no. Results show that membership was found to be statistically significant at 5 per cent level ( $p = 0.039$ ) and positively correlated with the TVP of the sampled farmers in Mthonjaneni. The prediction of the model is that the sampled farmers in Mthonjaneni who belong to one agricultural-related group or the other would likely realize

a higher TVP by a value of ZAR 202 compared to their counterparts who do not belong to any group. By contrast, membership of agricultural-related group has no significant effect on the TVP of the farmers in uMhlathuze. The combined analysis shows a positive correlation of membership of agricultural-related group with the TVP at 5 per cent ( $p=0.029$ ) level of significance. The prediction is that the sampled farmers in KCDM who belong to one agricultural-related group or the other would realize a higher TVP by a value of ZAR 201 than their counterparts who do not belong to any group.

#### **7.4 Discussion**

Results obtained on both Mthonjaneni and uMhlathuze reveal that the adoption of CSA positively correlates with TVP which was used as a proxy for agricultural productivity in this paper. The OLS regression model predicts that the adoption of an additional CSA practice would increase the TVP of the sampled farmers by about ZAR 309 and ZAR 212 in Mthonjaneni and uMhlathuze respectively. The OLS regression model for the combined analysis also predicts that the adoption of an additional CSA practice will increase TVP by ZAR 199 in KCDM. The positive correlation of CSA adoption with the TVP, a proxy for agricultural productivity, affirms one of the objectives of CSA, which is improving productivity (FAO (2010; 2013); Lipper *et al.* (2014). This corroborates studies by Vera *et al.* (2017), Wekesa *et al.* (2018) and Onyeneke *et al.* (2018) who are of the opinion that CSA adoption has positive impacts on agricultural small-scale production. However, based on comparison, there is a stronger effect of CSA adoption on agricultural productivity among small-scale farmers in Mthonjaneni than their counterparts in uMhlathuze. This could be because there more farmers in Mthonjaneni in the high user category of CSA adoption in Mthonjaneni than in uMhlathuze (see Section 5.3.2\*).

The OLS regression model further predicts that the older the sampled farmers are in uMhlathuze Municipality, the lower would be their TVP. This result confirms the finding of Obasi *et al.* (2013) that age is inversely related to agricultural productivity. This result reflects the descriptive evidence from the area showing low level of participation of young farmers in the area (as reported in chapter five of this thesis) which suggests that the level of involvement of young farmers will increase the agricultural productivity of the area. By contrast, age has no significant effect on agricultural productivity in Mthonjaneni Municipality. Results from the combined analysis show that age, also, has no significant influence on the agricultural productivity of the sampled farmers in KCDM.

The size of households of the farmers also positively correlates with the TVP of the sampled farmers in Mthonjaneni and uMhlathuze. Furthermore, the OLS regression model predicts that an increase in the number of household members would increase the productivity of the sampled farmers. Based on the results, an increase in household size is expected to have, approximately, the same effect on agricultural productivity. The regression model for the combined analysis also predicts an increased level of productivity with an increase in the number of household members for the district. An increase in household size is a potential increase in the workforce for farming activities in rural areas, which is expected to increase agricultural output (Gollin, 2014).

Results of income from off-farm sources predict that an increase in income from sources other than farming will decrease the TVP of the sampled farmers in Mthonjaneni. The negative influence of income from alternative sources could also be attributed to lesser commitment to farming activities. Divided attention is expected from farmers who have more than one source of income, particularly if they hold the alternative source in high esteem than farming. In contrast, there is no significant effect of income from off-farm sources on the productivity of the farmers in uMhlathuze. This is also the case with the combined analysis revealing that there is no significant effect of off-farm income on the productivity of the sampled farmers in the district.

Based on the prediction of the OLS regression model, the more the sampled farmers in Mthonjaneni and uMhlathuze practice farming (experience), the more productive they become. The OLS regression prediction for the combined analysis on the district reveals a result consistent with the findings from both local municipalities. These results agree with the conclusion of Obasi *et al.* (2013) that a positive and significant relationship exists between years of farming experience and agricultural productivity. The OLS regression model results also show a positive correlation between contact with extension workers and TVP. The regression model predicts that additional contact with an extension worker will increase the productivity of the sampled farmers. This is in line with the regression prediction for the combined analysis for the district. These results agree with the finding of Obasi *et al.* (2013) that productivity would significantly increase if there is an increase in contacts with extension workers. It is therefore expected that the productivity of the sampled farmers would increase significantly if the farmers are exposed to more extension advisory services.

Exposure to the media is another variable predicted by the OLS regression model to increase the agricultural productivity of the sampled farmers in uMhlathuze whereas it has no significant effect on the productivity of those in Mthonjaneni. This suggests that increasing the level of exposure of the sampled farmers in uMhlathuze to more information via the use of media would increase agricultural productivity in the area. The result from the combined analysis for the district is consistent with the finding from uMhlathuze. This could be because exposure to the media could amount to exposure to opportunities and information that could be of great assistance in agricultural production. This agrees with the argument of Seitova and Maharjan (2014) that one of the ways to enhance agricultural development and improve livelihood of rural dwellers is to facilitate information management in the agricultural sector.

The OLS regression model predicts that the sampled male small-scale farmers in Mthonjaneni are likely to realize a higher TVP from their farming activities compared to their female counterparts. Given the descriptive evidence of greater female participation in farming in South Africa and in the area (Section 5.3.1; Tshuma (2014)), this result suggests that more male participation in small-scale farming would likely increase the agricultural output of the area. This finding agrees with the argument of Koirala *et al.* (2014) that women are less efficient in farming but contradicts the report of Karamba and Winters (2015) that there is no significant difference between male and female gains in agricultural productivity. By contrast, gender has no significant effect on agricultural productivity in uMhlathuze. This is consistent with the result from Mthonjaneni and from the combined analysis that male farmers in the district are likely to realize more TVP than their female counterparts.

The marital status of the farmers positively correlates with the TVP of the farmers in both municipalities. The regression model predicts a higher TVP for the married farmers as against their single counterparts although based on the comparison, the margin of the comparative advantage of being married in Mthonjaneni is higher than in uMhlathuze. The OLS regression model for the combined analysis also predicts a higher TVP for the sampled married farmers than for the single farmers in the district. This could be as a result of domestic responsibilities and obligations on the part of the married farmers.

The nature of agricultural production shows a significant effect on the TVP of the sampled farmers in both municipalities. The regression model predicts that those who integrate crop production with livestock production in both municipalities would enjoy higher productivity than their counterparts who are exclusively into crop production. Although there is no

significant difference between the TVP of those who are exclusively into crop production and those who are into livestock production in uMhlathuze, the OLS regression model predicts a higher TVP for those entirely into crop production as against those solely into livestock production in Mthonjaneni. This suggests that the integration of crop and livestock production promises higher agricultural productivity, while the sampled crop farmers in Mthonjaneni tend to gain more than their counterparts who are into livestock production.

Furthermore, the OLS regression model predicts higher productivity for the farmers in Mthonjaneni who belong to an agricultural-related group (association) or to more groups than their counterparts who do not. This suggests there is a productive contribution of the agricultural-related groups that the sampled farmers in Mthonjaneni identify with, to their productivity. The result from the combined analysis for the district is consistent with the findings from Mthonjaneni. These results confirm the conclusion of Onogwu *et al.* (2017) that membership of farm-based organizations significantly and positively influences farmers' productivity. Furthermore, membership of an agricultural-related group has no significant effect on the productivity of the sampled farmers in uMhlathuze.

## **7.5 Conclusion and policy implications**

There is the need to evaluate the adaptation and mitigation potentials of different practices and technologies in agriculture from the local to global stage. This paper contributes to the literature and evidence base by examining the effects of CSA to the agricultural productivity of small-scale farming systems. It deviates from conventional approaches that focus on a single practice but considered multiple CSA practices. The outcome is that CSA adoption can improve the productivity of small-scale farmers. The reason for assessing the effect of CSA adoption on farmers' productivity is to inform the farming populace of the study area/ s and stakeholders in the agricultural sector of the potential of CSA to improve and sustain farm-scale and productivity.

Findings from this paper show that contact with extension agents has a positive effect on agricultural productivity. Factors such as marital status, household size and nature of agricultural production activity also positively influence the productivity of small-scale farmers in the studied municipalities. While gender and membership of agricultural-related group positively influence productivity in Mthonjaneni, farming experience and exposure to the media had a positive influence on productivity in uMhlathuze. Income from off-farm sources

negatively affected productivity in Mthonjaneni, while age negatively affected productivity in uMhlathuze.

Based on the findings of this study, it is recommended that extension agents should work on increasing their number of visits to small-scale farmers and encourage them to embrace agricultural practices, that fit into the CSA profile, which can help them improve their level of agricultural productivity. Agricultural-related groups, associations or societies should be encouraged among small-scale farmers and used as platforms in educating farmers on the challenges they are facing, particularly climate change issues and coping mechanisms that they can adapt to overcome their challenges. The government and agricultural stakeholders should synergize their efforts in creating structures that will help improve farmers' exposure to the media so that they can be well armed with essential climate-smart information. The involvement of agricultural-related organizations in campaigning for more involvement of youths and men in agricultural production is critical. The governments should embark on programs and projects that will make agriculture more attractive to youths.

Researchers are encouraged to conduct similar but wider research into the contribution of CSA to agricultural productivity, particularly among small-scale farmers in South Africa. This research can be further elaborated, for example, by increasing the sample size and extending the research to other areas in South Africa to enhance the reliability of the findings. Besides, impact assessment studies can be carried out on climate-smart projects and programs designed for small-scale agriculture. This will help in having a holistic overview of the impacts of such projects or programs, particularly on small-scale farming households.

### **Author Contributions**

V.O.A. conceived and designed the study. V.O.A collected and analyzed the data for the study and drafted the manuscript. M.S. and A.O. supervised the study. M.S and A.O scrutinized and verified the research process, methods and the manuscript. All authors contributed to the outcome of the manuscript.

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**Conflict of interest**

The authors declare no conflict of interest.

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## CHAPTER EIGHT<sup>5</sup>

### THE EFFECT OF CLIMATE-SMART AGRICULTURE ADOPTION ON HOUSEHOLD FOOD SECURITY IN SMALL-SCALE PRODUCTION SYSTEMS: EVIDENCE FROM KING CETSHWAYO DISTRICT MUNICIPALITY

#### Abstract

The challenge of food insecurity at the household level in South Africa is exacerbated by climate change, given the vulnerability of small-scale farming system to climate change impact. Climate-smart agriculture, however, has been recommended a probable solution in the small-scale farming system. This paper analyzed the food security status and the effect of the adoption of CSA practices on the food security status of small-scale farming households in KCDM through a comparison of two local municipalities – Mthonjaneni and uMhlathuze. The municipalities were selected based on of their agricultural potentials. A multi-stage sampling technique was used to select 327 small-scale farmers from whom data was collected with the aid of a structured questionnaire. The data was analyzed with descriptive statistics, HDDS, HFCS, Composite Score and the Binary Logistic Regression Model. Results show that about 38 per cent of the sampled farmers in the district, were in the high dietary diversity category ( $HDDS \geq 7$ ), 38 per cent in the medium category ( $HDDS = 4 - 6$ ) and 24% were in the low dietary diversity category ( $HDDS \leq 3$ ). The majority (80%) of the sampled farmers had an acceptable level of food consumption ( $HFCS > 35$ ). On the overall, the majority (62%, 60% and 62%) of the sampled farming households in Mthonjaneni, uMhlathuze and KCDM, respectively could be regarded as food secure. Further analysis shows that the adoption level of CSA had significant and positive influence ( $p < 0.01$ ) on the sampled farming households' food security status. The binary logistic regression model results predict that an increase in the CSA adoption level would increase the food security chances of the sampled farming households in both municipalities. Gender ( $p < 0.10$ ) had a significant positive effect on household food security in Mthonjaneni but had no significant influence on food security in uMhlathuze. Household food security was significantly and positively influenced by farm income (Mthonjaneni ( $p < 0.05$ ), uMhlathuze ( $p < 0.05$ )), income from non-farm sources (Mthonjaneni ( $p < 0.05$ ), uMhlathuze ( $p < 0.01$ )), farming experience (Mthonjaneni ( $p < 0.10$ ),

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<sup>5</sup> N/B This chapter is prepared as an article for submission to an accredited journal.

\* Text that has already been explained in the methodology chapter will be skipped, with only reference given to.

uMhlathuze ( $p < 0.01$ ) and household participation (Mthonjaneni ( $p < 0.05$ ), uMhlathuze ( $p < 0.01$ )). By contrast, household size (Mthonjaneni and uMhlathuze ( $p < 0.05$ )) and dependency ratio (Mthonjaneni ( $p < 0.10$ ), uMhlathuze ( $p < 0.05$ )) had a significant but negative effect on household food security status. This paper argues that the challenges of food insecurity are surmountable through intensified efforts including policy design and implementation. Small-scale farmers should incorporate CSA practices as much as possible to maximize their benefits and improve their productivity and chances of being food secure.

**Keywords:** Adoption, climate-smart agriculture, dietary diversity, farming household, food consumption score, food security, small-scale.

## 8.1 Introduction

Food availability is a huge challenge in developing countries (FAO, 2014). Food security is a situation in which household members have access to sufficient nutrition and culturally accepted food through socially acceptable means for healthy living (FAO, 2014). Conversely, food insecurity is a situation of uncertainty or limited access to adequate nutrition and food safety (FAO, 2008; Abdullah *et al.*, 2019). Food security, as a concept, is multidimensional, thereby making it challenging for policymakers to measure it accurately and target it with policies. Coleman-Jensen *et al.* (2016) describe food security in terms of consistency and dependable accessibility to sufficient food for active and healthy living.

This paper adopts the FAO definition of food security as “a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (FAO, 2008). The definition highlights four major components of food security – availability, stability, accessibility and utilization. Availability means that there is food in adequate quantity; accessibility means the ability to acquire the required quantity; sustainability refers to consistency in the access to food, and utilization relates to food quantity and quality at a sufficient level. People become vulnerable when there is uncertainty or insecurity with one or more of these four components in a food system (FAO, 2008; 2014).

Food insecurity is already a growing global concern as a result of the increasing number of people suffering from undernourishment which stands at about 12 per cent of the global at the current time (Abdullah *et al.*, 2019). Asia and Africa are profoundly affected as they account for about 92 per cent of those suffering from undernourishment globally. There are

approximately 226.4 million of the undernourished in Africa and 552 million in Asia (FAO *et al.*, 2013). Food insecurity seems to be particularly severe in Sub-Saharan Africa with the number of undernourished people in the region rising from 180 million between 1990 and 1992 to 220 million between 2014 and 2016 (FAO, 2015; Ogundari, 2017).

Food security can exist at different levels – global, regional, national, local, household or individual. The determinants at each of these levels differ from one another. Food security, being multidimensional can be caused by several factors such as climate change, national disasters, conflicts and social norms (Abdullah *et al.*, 2019). It has received a lot of attention from policymakers owing to the impact hunger and malnutrition have on people (Tibesigwa *et al.*, 2016). Due to its multidimensional nature, and in spite of the different food security indicators in the literature, there is no consensus on definitive and cord indices by which food security can be measured and monitored at micro and macro levels (Carletto *et al.*, 2013; Magrini & Vigani, 2014; Ogundari, 2017). Choosing from available food security indicators would involve trade-offs since food security as a concept is inherently hierarchical (Magrini & Vigani, 2014).

This paper adopts the household dietary diversity as an indicator of household food security. To supplement the results from the household dietary diversity measure, the food consumption score is also applied. The food consumption score is adopted because it provides the possibility of estimating both dietary and food frequencies. This paper analyzes the food security level of small-scale farming households in terms of their dietary diversity. Hendriks *et al.* (2016) highlight the lack of a consistent classification of indicators for analyzing household food security in South Africa. There is the need to ensure that efforts towards enhancing food security do not end up as failures but instead as plans that yield measurable and sustainable results. Such sustainable results are needed for practical improvement in the livelihood of people, mainly rural dwellers.

Many African countries are faced with the tasks of poverty alleviation and enhancing food security. However, many of these countries, sometimes, have to make sacrifices in the effort to mitigate the effects of climate change and GHG emission (Vermeulen, 2014; World Bank, 2016). A good example is the stopping of the production of ruminants which contribute to methane build up in the atmosphere, yet is important for peoples' livelihoods and meeting growing food demands (FAO *et al.*, 2013). The challenges facing these countries include poor returns from the agricultural sector as well as issues in the eco-system such as pests and weed

control, nutrient cycling, nitrogen fixation, soil regeneration as well as food security for the population as a whole but in particular for small-scale farmers (Teklewold *et al.*, 2013; Nwajiuba *et al.*, 2015).

There are reports of a significant reduction in fallow periods, especially in Sub-Saharan Africa (Nwajiuba *et al.*, 2015). Coupled with the reduction, unfortunately, are poor investments in sustainable agricultural intensification and moving away from diversification to embrace sole cropping (Nwajiuba *et al.*, 2015). This has led to low agricultural production and food insecurity especially in the face of climate change (Wekesa *et al.*, 2018). Climate change has been identified to be a significant challenge of the 21st Century and a big threat to food production (FAO *et al.*, 2013).

Pacing up with climate change is becoming more complicated since the ability to hold temperature increase in 2°C threshold is getting curtailed (IPCC, 2014). This comes with its repercussions, and the world may just have to be prepared to deal with it. One of the pressing consequences of climate change is the pressure on the agricultural sector to meet the food demand of the ever-growing global population which is expected to reach 9.1 billion by 2050 and more than 10 billion by the end of the century (World Bank, 2015; 2016). The agricultural production system is therefore in urgent need of serious transformation.

Climate change is a growing threat to food production and household well-being particularly at the local level in many rural areas where it is exacerbating problems of malnutrition, hunger and poverty (Lukano, 2013; Ncube *et al.*, 2016). The majority of the small-scale farmers in Africa rely primarily on farming for their livelihood (Ochieng *et al.*, 2017). For the protection and sustenance of their livelihood and to ensure their food security, it is essential they build adaptive capacity and resilience towards climate change. Coping with the impacts of climate shocks and natural disasters depends to a great extent on resilience (Wineman *et al.*, 2017).

The adoption of CSA practices is one way to combat the impacts of climate change (FAO *et al.*, 2013). However, in spite of the obvious benefits of CSA and the growing advocacy for farmers to embrace it, there is still a dearth of evidence on the impact of CSA on food security, particularly in relation to small-scale farmers (Arslan *et al.*, 2014; Kabubo-Mariara & Kabara, 2015). There is the need for better information on and understanding of the potential welfare effects of CSA with regards food security. This will provide insight for policymakers and stakeholders on what could be the best strategies to adopt in mainstreaming CSA and enhancing its usage and effectiveness in small-scale agriculture.

## 8.2 Materials and Methods

### 8.2.1 Study Area

As earlier stated in chapter four of this thesis, the research study was conducted in KCDM of KZN Province of the Republic of South Africa. Refer to chapter three (section 3.2\*) for detailed information on the description and selection of study area/ s.

### 8.2.2 Research Design

The study followed a cross-sectional research design. Refer to chapter three (section 3.7\*) for the detailed information on the description and rationale of the chosen design.

#### *Conceptual framework*

Figure 8.1 illustrates how this paper conceptualizes the food security analysis of the sampled farming households.

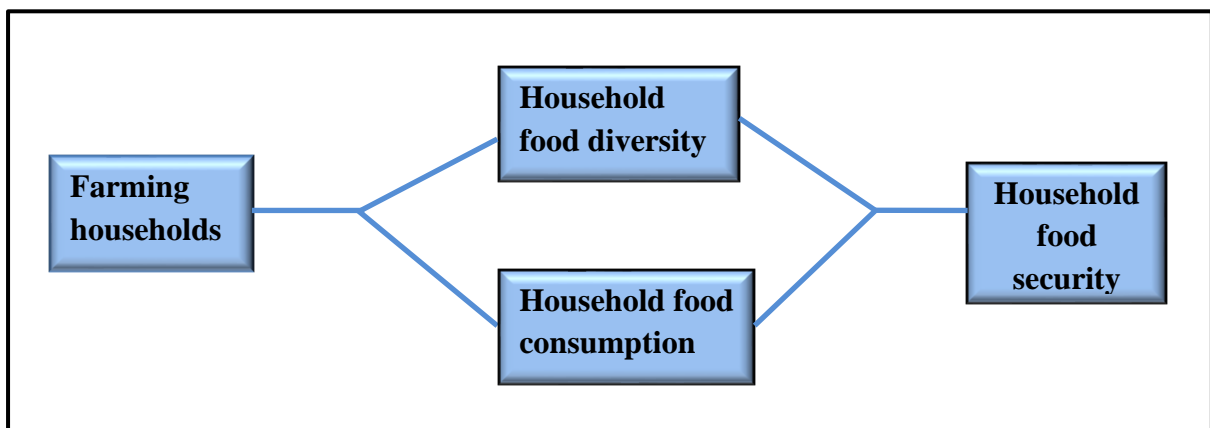


Figure 8. 1: Conceptual framework – Influence of CSA adoption on agricultural productivity  
Source: Author's conceptual design

This paper conceives household food security as household dietary diversity. Household food consumption is adopted as a supplementary approach to household dietary diversity in analyzing household food security.

Refer to chapter three (section 3.7.1\*) for further information on the description of the conceptual framework.

### **8.2.3 Sampling Technique and Data Collection**

The sampling technique and data collection procedure is the same as described in chapter four. Refer to chapter three (section 3.8.1\*) for detailed information on the sample size calculation and data collection.

### **8.2.4 Data Analysis**

#### **8.2.4.1 Household Dietary Diversity**

The HDDS was used to determine the food security status of respondents. Following Mango *et al.* (2014) and Wekesa *et al.* (2018), the study used the HDDS as a proxy to measure household food security. According to the FAO (2011), HDDS is a qualitative free recall of all foods or drinks that have been consumed by any household in a 24-hour period for 7 days and it is measured by adding the number of consuming food groups over the reference period (Kassie *et al.*, 2008; Uruguchi, 2012).

There is extensive scholarship on HDDS as an essential proxy for food security (Mirmiran *et al.*, 2006; Ekesa *et al.*, 2008; Mango *et al.*, 2014). Goshu *et al.* (2013) notes that HDDS has a high correlation with factors such as adequate household's intake of calories, protein and other nutrients, which is an advantage for adopting it as a proxy for measuring food security. There is better prediction from indicators based on food groups relative to those based on individual foods. This is because it is possible for a household to meet the energy requirements of its members while remaining deficient in other nutrients' requirements. This gives HDDS a comparative advantage as an indicator. Dietary Diversity reveals the extent to which there is variety in the food consumption of a household as well as the household economic capacity for the consumption of a variety of foods (Mango *et al.*, 2014).

A high HDDS indicates an acceptable level of diversity in the household diet, which will most likely balance micronutrient intake. A low HDDS, on the other hand, suggests a high intake of starch staples with unbalanced micro-nutrients intake (Arimond *et al.*, 2010; Goshu *et al.*, 2013). The score is calculated by counting the number of food groups underconsumption at the household level, not counting those consumed outside the household, and each food group carries a weight of one. The literature shows a powerful and positive correlation between HDDS and food security (Nyikahadzoi *et al.*, 2012). Table 8.1 shows the categorization of food items into food groups for HDDS estimation.

Table 8. 1: Categories of Food Groups

Food Groups	Score
1. Cereals Foods such as bread, rice, or any food made from wheat, maize, rice, sorghum, millet or any local grain	1
2. Roots and Tubers Foods such as potatoes, cassava, manioc or any food from roots or tubers	1
3. Vegetables Spinach, Cabbage or any other vegetable	1
4. Fruits	1
5. Meat, Poultry and Offal Beef, pork, lamb, goat, rabbit, wild game, chicken, other birds, liver, kidney, heart or meats from other organs	1
6. Eggs	1
7. Fish and Seafood	1
8. Pulses, Legumes and Nuts Foods such as beans, peas, lentils, nuts or any food made from them	1
9. Milk and Milk Products Foods such as cheese, yoghurt, milk or any milk product	1
10. Oil and Fats	1
11. Sugar and Honey	1
12. Miscellaneous Any other foods such as condiments, coffee or tea	1
<b>Total Score</b>	<b>12</b>

**Key:** Answering Yes to any of the food group attracts a score of 1 for the food group, while No attracts a score of 0

Source: (Huluka & Wondimagegnhu, 2019)

There is also evidence from multi-country analyses that household level dietary diversity is strongly correlated with per-capita consumption and energy availability implying that HDDS could be an essential indicator for household food security (Mango *et al.*, 2014). Uruguchi (2012) has criticized the use of HDDS, stating that even though it can show changes in dietary energy consumption of households, it is not easy to give the empirical demonstration of its significance in nutrient adequacy. The HDDS does not include the estimation of the quantity of food that is lacking because it cannot be used for direct quantification of the amount of food

consumed. Also, it does not explain the causes of consumption patterns. The HDDS as a proxy measure of food security captures only the qualitative aspect of food security in terms of food consumption according to food groups, which is contrary to other measures of food security estimation method such as cost-of-calorie estimation. In spite of these weaknesses, HDDS remains a good and vital proxy for nutrient adequacy for households, thereby making it still an essential and relevant measure of household food security (Mango *et al.*, 2014).

In this study, the sampled households were requested to make a recall of the food they consumed in the 24 hours prior to interviews. The foods and drinks stated were then categorized into 12 standardized food groups. Responses gathered were either yes, which was scored as 1 or no, which was scored as 0. The food groups are cereals; root and tubers; vegetables; fruits; meat, poultry and offal; eggs; fish and seafood; pulses, legumes and nuts; milk and milk products; oil and fats; sugar and honey; miscellaneous (FAO, 2008; Taruvinga *et al.*, 2013; Kennedy *et al.*, 2015). Data on the dietary diversity of the sampled households were collected using a 24-hour recall dietary intake. A list of food items taken in the last 24-hours was put on record. Although the 24-hour recall exercise does not wholly reveal the habitual diet of an individual, it does give an insight into the population's diet.

The 24-hour recall exercise has been established to be very useful in monitoring progress or target interventions (Muhammad-Lawal *et al.*, 2017). This study used the 24-hour recall period since it is less subject to recall error, has minimal complexity for respondents and can be established to conform to the recall period adopted in many studies on dietary diversity and food security (Arimond *et al.*, 2010; Muhammad-Lawal *et al.*, 2017). Dietary diversity becomes more prominent if a particular household consumes at least one food item from a food group in the past 24-hours. In line with the recommendations of FAO, scores were allocated for each of the consumed food group, with the mean of the HDDS as the benchmark for dividing the sampled households into food secure or non-food secure group (FAO, 2008).

#### **8.2.4.2 Household Food Consumption**

The HDDS does not analyze household food consumption in terms of quantities consumed (Ogundari, 2017). The HFCS therefore was used as a supplementary approach to support the findings from HDDS. The HFCS is estimated by categorizing the household food data into eight food groups, which are main staples, pulses, vegetables, fruits, meat/fish, milk, sugar and oil. This is followed by aggregating the frequency of consumption of food items in each group. The frequency obtained is weighted with the nutritional value of the food groups by multiplying

the aggregate score from the frequency of consumption and its weighting. The scores from the weighted food group are summed up, giving a continuous measure of HFCS. Table 8.2 shows the food groups for estimating HFCS with their corresponding weightings.

Table 8. 2: Weight attached to Food Groups

	<b>Food Groups</b>	<b>Weight Attached</b>
1.	Main Staples	2
2.	Pulses	3
3.	Vegetables	1
4.	Fruit	1
5.	Meat/Fish	4
6.	Milk	4
7.	Sugar	0.5
8.	Oil	0.5

Source: (World Food Program, 2008; Marivoet *et al.*, 2019)

The continuous measure of HFCS obtained is then used to determine the household's food consumption status based on the following threshold: 0 – 21 (poor), 21.5 – 35 (borderline) and > 35 (acceptable). Household Food Consumption Score was adopted because it increases the possibility of calculating dietary diversity and food frequency.

#### **8.2.4.3 Binary Logistic Regression Model**

A binary logistic regression model was used to analyze the effect of the adoption of CSA practices on the food security status of the farming households. The binary (dummy) variable on the food security status (developed from the HDDS) of the sampled households was the dependent variable, while the composite score on the adoption of CSA practices and other hypothesized variables were the predictor variables (section 5.2.4). Although, several methods have been adopted in literature to analyze data involving binary outcomes for this study; a logit model was selected over linear probability and probit models. The rationale behind the choice of a logit model for this study is the simplicity of its structural form and the interpretability of its outcome, although the choice of link function for binomial regression could sometimes be subjective. A logit model has a standard logistic distribution of errors (Bogale & Shimelis, 2009; Green, 2012).

Following Bogale and Shimelis (2009), the logistic regression model is expressed as:

$$P_i = F(Z_i) = \frac{1}{1 + e^{-(\alpha + \sum \beta_i \chi_i)}} \quad (16)$$

Where:

$P_i$  = Probability that a farmer is food secure given  $\chi_i$

$\chi_i$  = A vector of regressors

$\alpha$  and  $\beta$  = Regression parameter to be estimated

$e$  = The base of the natural logarithm

A logistic model is better expressed in the form of the odds and log of odds to make the interpretation of coefficients easier. The odds ratio implies the ratio of the probability ( $P_i$ ) that a farmer is food secure or not; to the probability ( $1 - P_i$ ) that the farmer is not food insecure.

$$\frac{P_i}{1 - P_i} = e^{z_i} \quad (17)$$

Taking the natural logarithm of the equation, we have:

$$\ln \frac{P_i}{1 - P_i} = Z_i = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_w X_w \quad (18)$$

When the error term,  $e_i$  factored in  $t$ ; the equation is expressed as:

$$Z_i = \alpha + \sum_{i=0}^w \beta_i X_i + e_i \quad (19)$$

$Z_i$  will take the value of 1 if a farm household is food secure and 0 if otherwise

The explanatory variables used were the same as those stated in section 5.2.4.

### ***Model Fitness for the Binary Logistic Regression Model***

The likelihood ratio chi-square test value for the models fitted for the responses from Mthonjaneni and uMhlathuze and the one fitted for the combined analysis are 79.06, 54.36 and 121.53, respectively. The likelihood ratio chi-square test shows whether at least one of the regressors' coefficient in the model is equal to zero or not. The  $\text{prob} > \text{chi}^2$  is the probability of obtaining the value of the chi-square statistics if there is, in fact, no effect of the regressors, taken together, on the dependent variable. The  $\text{prob} > \text{chi}^2$  value obtained for each of the three models is 0.0000. A small value of less than 0.0001 obtained for these models means that at least one of the regression coefficients in each of the models is not equal to zero, implying that the overall models are statistically significant.

Furthermore, a Hosmer and Lemeshow goodness-of-fit test was run to test and see if the fitted models adequately explain the observed outcome from the data. A small difference between the observed and fitted values and no systematic contribution of the difference to the error of a structured model indicates a fit model (Hosmer & Lemeshow, 2000). The Hosmer-Lemeshow chi2 test's result for the model fitted for the responses gathered from Mthonjaneni shows a value of 18.04 with a prob>chi2 value of 0.8794. The result for the model fitted for uMhlathuze shows a value of 19.07 with a prob>chi2 value of 0.8258 while that of the combined analysis shows an F value of 33.80 with a prob>chi2 value of 0.5140. The results obtained from these tests indicate a good model fit of the data.

### 8.3 Results

#### 8.3.1 Result on Household Dietary Diversity

The analysis follows on the scholarship of Taruvinga *et al.* (2013) and Muhammad-Lawal *et al.* (2017) to classify households with dietary diversity scores of  $\leq 3$  in the category of low dietary diversity; those with scores between 4 – 6 were classified in the medium category while those with scores  $\geq 7$  were classified in the high category. Based on the categorization that has been made, three strata have been created, which are the low dietary category, medium dietary diversity category and high dietary diversity. Results in Table 8.3 show that the average dietary score for the sampled farming households in Mthonjaneni Municipality is 5, while it is 6 for uMhlathuze Municipality. Results from the combined analysis also show an average dietary score of 6 for KCDM. About 37 per cent of the sampled farming households in Mthonjaneni fall into the high dietary diversity category, while their counterparts in uMhlathuze who are also in the high dietary diversity category are about 39 per cent. The combined analysis shows that about 38 per cent of the sampled farming households in KCDM fall into the high dietary diversity category. Belonging to the high dietary diversity category means their dietary diversity score fall between 6 and 12. Table 8.3 summarizes the categories of the sampled small-scale farmers based on their dietary diversity score.

Table 8. 3: Categories of the Sampled farmers based on Dietary Diversity Score

Categories of Dietary Diversity	Mthonjaneni		uMhlathuze		Combined Analysis (KCDM)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Low Dietary Diversity	24	22.0	55	25.2	79	24.2

Medium Dietary Diversity	45	41.3	78	35.8	123	37.6
High Dietary Diversity	40	36.7	85	39.0	125	38.2
<b>Total</b>	<b>109</b>	<b>100.0</b>	<b>218</b>	<b>100.0</b>	<b>327</b>	<b>100</b>
<b>Mean Score of Dietary Diversity</b>	<b>5.35 (± 2.12)</b>		<b>5.61 (± 2.46)</b>		<b>5.53 (± 2.35)</b>	

Source: Survey Data (2018/19)

Table 8.3 further shows that about 41 per cent of the sampled farming households in Mthonjaneni fall in the medium dietary diversity category (HDDS of 4 – 5), while 36 per cent of those in uMhlathuze fall in that category. The combined analysis reveals that 38 per cent of the sampled farming households in KCDM are in the medium dietary diversity category. Results further show that 22 per cent of the farming households in Mthonjaneni fall in the low dietary diversity category (HDDS of  $\leq 3$ ), while 24 per cent of those in uMhlathuze are in that category. Results for the combined analysis show that about 24 per cent of the sampled farming households in KCDM fall in the low dietary diversity category.

The dietary diversity score was then used to further categorize the households into food secure and food insecure groups, using the mean HDDS as a proxy for food security, following FAO guidelines. Table 8.4 summarizes the categories of the sampled farming households with respect to food security.

Table 8. 4: Categories of the Sampled Farming Households with respect to Food Security

Categories of Household based on Food security	Mthonjaneni		uMhlathuze		Combined Analysis (KCDM)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Food Insecure	42	38.5	88	40.4	130	39.8
Food Secure	67	61.5	130	59.6	197	60.2
<b>Total</b>	<b>109</b>	<b>100.0</b>	<b>218</b>	<b>100.0</b>	<b>327</b>	<b>100</b>

Source: Survey Data (2018/19)

The respondents with a HDDS which is less than the mean HDDS were deemed as food insecure, while those with an HDDS that is above the mean HDDS were deemed as food secure. Table 8.4 shows that the majority of the sampled farming households in both Mthonjaneni (62%) and uMhlathuze (60%) Municipalities fall into the food secure category based on their dietary diversity score. Results from the combined analysis show that about 60 per cent of the

sampled households in the district fall into the food secure group. These results imply that the majority of the households in the study area may be deemed as food secure.

### **8.3.2 Food Group Consumption Pattern**

The pattern reveals that food groups such as cereals (81%), vegetables (74%) and pulses, legumes and nuts (65%) were highly consumed in Mthonjaneni, while food groups such as fish and seafood (24%) and eggs (25%) were not commonly consumed. Households in uMhlathuze consumed cereals (77%), roots and tubers (68%) and oil and fats (62%), while food groups such as fish and seafood (21%) and fruits (28%) were not very commonly consumed. A combined analysis shows that cereals (78%) and vegetables (60%) were in high consumption in the district while fish and seafood (22%) and fruits (32%) were not commonly consumed. Figure 8.2 shows the pattern of consumption of the food groups.

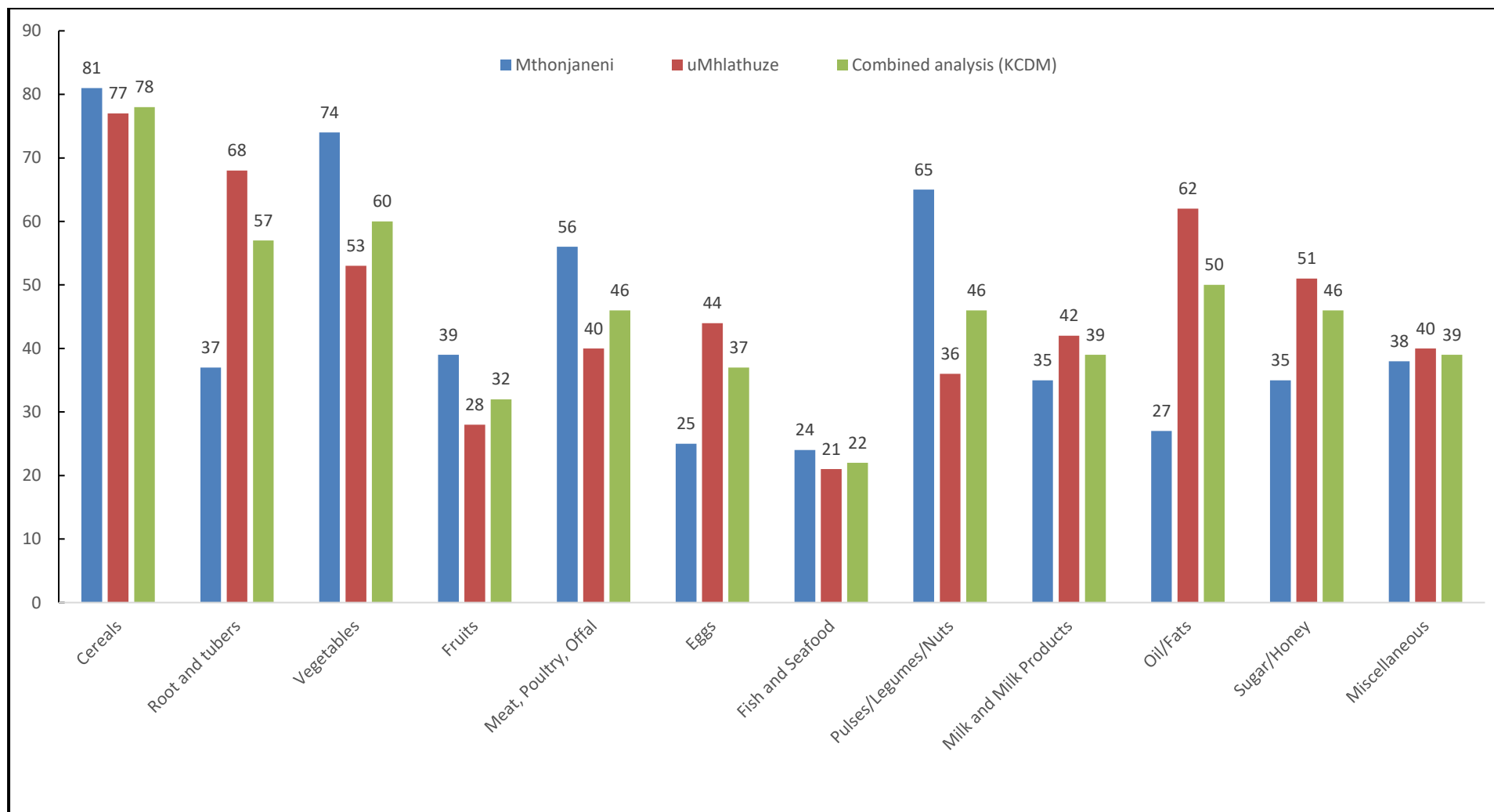


Figure 8. 2: Food Group Consumption Pattern in Mthonjaneni, uMhlathuze and KCDM  
Source: Survey Data (2018/19)

### 8.3.3 Result on Household Food Consumption

The HDDS does not reveal the quantity of food consumed by households. The study further estimated a HFCS, which is a form of HDDS with weighted frequencies and operates as an indicator of dietary diversity and frequency of consumption. Table 8.5 shows that the majority (80% and 81%) of the sampled farming households in Mthonjaneni and uMhlathuze respectively had an acceptable HFCS. About 18 and 16 per cent of the sampled households in Mthonjaneni and uMhlathuze had a borderline HFCS respectively and only 3 and 4 per cent of the sampled households in Mthonjaneni and uMhlathuze had a poor HFCS. Results from the combined analysis show that the majority (80%) of the sampled small-scale farming households in KCDM had an acceptable HFCS, about 17 per cent had a borderline HFCS and only 3 per cent had a poor HFCS.

Table 8. 5: Categorization of the Sampled Households based on Household Food Consumption Score

Categories of Household based on Household Food Consumption Score	Mthonjaneni		uMhlathuze		Combined Analysis	
	Frequency	Percentag e	Frequency	Percentag e	Frequency	Percentag e
0 – 21 (Poor)	3	2.8	8	3.7	11	3.4
21.5 – 35 (Borderline)	20	18.4	34	15.6	54	16.5
> 35 (Acceptable)	86	78.9	176	80.7	262	80.1
<b>Total</b>	<b>109</b>	<b>100.0</b>	<b>218</b>	<b>100.0</b>	<b>327</b>	<b>100.0</b>

Source: Survey Data (2018/19)

### 8.3.4 Result on the Effect of CSA adoption on Food Security

Table 8.6 presents the empirical results of the binary logistic regression used in examining the effect of CSA adoption on the food security status of the sampled households in both Mthonjaneni and uMhlathuze municipalities. Results reveal that CSA adoption level significantly affects the food security status of the sampled households in both municipalities. The level of adoption of CSA practices by the farming households was entered into the model as a continuous variable using the composite score generated from the number of practices adopted. Table 8.6 summarizes the results on the effect of CSA adoption level and other hypothesized variables on the food security status of farming households.

Table 8. 6: Effect of CSA Adoption on the food security status of sampled farming households

Parameter	Mthonjaneni			uMhlathuze			Combined Analysis		
	Odds Ratio	Std. Error	P > / z /	Odds Ratio	Std. Error	P > / z /	Odds Ratio	Std. Error	P > / z /
Level of CSA adoption	2.515659***	0.5029978	0.000	1.302637***	0.0765899	0.002	1.610033***	0.0547226	0.000
Age	-1.031605	0.035067	0.360	0.9752187	0.0180046	0.174	1.003217	0.0135535	0.812
Educational status	1.137837	0.0906516	0.105	0.9381583	0.0344995	0.183	1.007348	0.0275309	0.789
Household Size	-0.7990815**	0.1226755	0.044	-1.094267**	0.0676322	0.045	-1.009003*	0.0459989	0.044
Dependency Ratio	-1.086792*	0.1555353	0.061	-1.036544**	0.0515667	0.041	-1.00429*	0.0391041	0.074
Farm Income	1.086792**	0.0006433	0.036	0.9997154**	0.0001924	0.039	1.000118**	0.0001395	0.039
Off-farm Income	1.000314**	0.000146	0.031	0.9999574**	0.0000838	0.016	1.00429**	0.0391041	0.018
Farming experience	0.9298699*	0.0369241	0.059	1.019838***	0.0184264	0.007	0.9777093*	0.0134052	0.063
Home Distance to Farm	1.277054	0.7557382	0.679	1.819891	0.7568147	0.150	1.258537	0.3453182	0.402
Household participation in farming	2.231201**	0.2132317	0.030	1.104757***	0.1091589	0.013	1.224477**	0.0860297	0.041
Gender	2.760467*	2.18272	0.099	1.982091	0.6979752	0.152	1.244681	0.3443931	0.429
Marital Status									
Married	1.911264	2.110316	0.557	0.7469035	0.3631076	0.548	0.9351287	0.3746479	0.867
Widowed	1.34507	1.938224	0.837	1.364868	0.7725494	0.583	1.545117	0.7195334	0.350
Constant	0.0002922	0.0006914	0.001	0.4028359	0.4587267	0.425	0.1151714	0.0940368	0.008
<i>Likelihood Ratio Chi-Square Test of the Model</i>	<i>Chi2(13) = 79.06, Prob &gt; Chi2 = 0.0000</i>			<i>Chi2(13) = 54.36, Prob &gt; Chi2 = 0.0000</i>			<i>Chi2(13) = 121.53, Prob &gt; Chi2 = 0.0000</i>		
<i>Hosmer-Lemeshow Test of Goodness-of-fit</i>	<i>Chi2(8) = 18.04, Prob &gt; Chi2 = 0.8749</i>			<i>Chi2(8) = 19.07, Prob &gt; Chi2 = 0.8258</i>			<i>Chi2(8) = 33.80, Prob &gt; Chi2 = 0.5140</i>		

\*\*\*, \*\*, \* denotes statistical significance of 1%, 5% & 10 % level

Source: Survey Data (2018/19) computed from STATA 14

Results show that the level of adoption of CSA practices positively correlates with the food security status at 1 per cent level of significance in both Mthonjaneni ( $p = 0.000$ ) and uMhlathuze ( $p = 0.002$ ). The model predicts that the adoption of an additional CSA practice would increase the odds of a small-scale farming household being food secure by a factor of 3 in Mthonjaneni, but by a factor of 1 in uMhlathuze. The results imply that the adoption of CSA practices would increase the chances of the food security status of the sampled households in both Mthonjaneni and uMhlathuze. However, CSA adoption has a higher chance of influencing household food security in Mthonjaneni than in uMhlathuze. Results from the combined analysis also show that the adoption of CSA practices positively correlates with the food security status of the sampled households in KCDM at 1 per cent level of significance ( $p = 0.000$ ). The model predicts that the adoption of an additional CSA practice would increase the odds of the sampled farming households being food secure by a factor of 2. This result implies that the adoption of CSA practices will increase the chances of food security of the sampled small-scale farming households in KCDM.

The household size variable was entered in the model as a continuous variable using the number of members of the household. Household size was found to be statistically significant at 5 per cent level and negatively correlated with food security in both Mthonjaneni ( $p = 0.044$ ) and uMhlathuze ( $p = 0.045$ ). The model predicts that an additional member to the household would decrease the odds of the household being food secure by a factor of 1 in both municipalities. In addition, results from the combined analysis show that household size negatively correlates with food security status at 5 per cent level of significance ( $p = 0.044$ ). The prediction of the model is that an additional member of the household would decrease the odds of a household being food secure by a factor of 1. These results imply that the larger the household size, the lower the chances of being food secure in both municipalities and the district municipality.

Dependency ratio was entered in the model as the ratio of the non-working population to the working population in the households. Dependency ratio was also entered in the model as a continuous variable. The dependency ratio was found to be statistically significant and has a negative correlation with the food security status of the sampled farming households in Mthonjaneni and uMhlathuze at 10 per cent ( $p = 0.061$ ) and 5 per cent ( $p = 0.041$ ) levels of significance, respectively. The model predicts that a unit increase in the dependency ratio of the sampled households would decrease the odds of being food secure by the sampled farming households in both Mthonjaneni and uMhlathuze by a factor 1. This implies that the higher the dependency ratio of the households, the lesser the chances of being food secure. Results from

the combined analysis show that the dependency ratio of the sampled farming households is statistically significant and negatively correlates with food security status at 10 per cent level of significance ( $p = 0.074$ ). The prediction of the model is that an additional member of the household would decrease the odds of the household being food secure by a factor of 1.

Farm income was entered in the model as a continuous variable and was found to be statistically significant and to positively correlate with household food security status at 5 per cent levels of significance in both Mthonjaneni ( $p = 0.036$ ) and uMhlathuze ( $p = 0.039$ ). Likewise, income from off-farm sources was entered into the model as a continuous variable and was found to be statistically significant and to positively correlate with household food security status at 5 per cent level of significance in Mthonjaneni ( $p = 0.031$ ) and uMhlathuze ( $p = 0.016$ ). The models predict that a rand increase in income from farm and off-farm sources would increase the odds of household food security status in both municipalities by a factor of 1. This implies that an increase in income from either source will increase the chances of a household being food secure in both municipalities. Results from the combined analysis show that both income from farm and off-farm activities were statistically significant and positively correlated with food security status of the household at 5 per cent ( $p = 0.039$  and  $p = 0.018$ ) level of significance respectively. The prediction of the model is that a rand increase in income from either source would increase the odds of a household being food secure by a factor of 1. This means that income increase, irrespective of the source of income would increase the chances of household food security in KCDM.

The farming experience was captured as years of farming experience and entered in the model as a continuous variable and was found to be statistically significant having a positive correlation with household food security status at 10 per cent ( $p = 0.059$ ) and 1 per cent ( $p = 0.007$ ) in Mthonjaneni and uMhlathuze, respectively. The models predict that a year increase in the experience of the sampled farmers would increase the odds of the household food security status in both municipalities by a factor of 1. This implies that the more the farming experience, the higher the chances of a household being food secure in both municipalities. Results from the combined analysis further show that the years of farming experience of the sampled farmers were statistically significant and positively correlates with food security status of the sampled farming households at 10 per cent level of significance ( $p = 0.063$ ). The model predicts that farming experience would increase the odds of household food security status by a factor of 1. This result implies that increased farming experience increase the chances of food security status of the sampled farming households in KCDM.

Household members participating in farming was entered in the model as a continuous variable. Results show that the participation of household members in farming activities is statistically significant and has a positive correlation with the food security status of the sampled households in Mthonjaneni and uMhlathuze at 5 per cent ( $p = 0.030$ ) and 1 per cent ( $p = 0.013$ ) levels of significance respectively. The models predict that the involvement of an additional member of the household in farming activities would increase the odds of a household being food secure by a factor of 2 in Mthonjaneni and a factor of 1 in uMhlathuze. This implies that the involvement of household members in farming engagement increases the chances of household food security. However, the involvement of household members in farming activities has a higher chance of influencing household food security in Mthonjaneni than in uMhlathuze. Results from the combined analysis also show that participation of household members in farming activities is statistically significant and positively correlates with food security status of households at 5 per cent level of significance ( $p = 0.041$ ) in KCDM. The model predicts that participation of household members in farming activities would increase the odds of a household being food secure by a factor of 1. This result implies that increased participation of household members in farming activities would increase the chances of food security of the sampled households in KCDM.

Gender was entered into the model as a dummy categorical variable. Results show that gender is statistically significant at 10 per cent level ( $p = 0.099$ ) and positively correlates with the food security status in Mthonjaneni Municipality. The model predicts that the odds of households, with a male taking responsibility of the household farming activities, would be food secure 3 times than that of households with a female taking care of the farming activities. This implies that households with a male responsible for farming activities stand a better chance of being food secure than households with farming responsibilities overseen by a female. In contrast, the gender of the person responsible for household farming activities has no significant effect on the food security status of the sampled farming households in uMhlathuze. Results from the combined analysis also show that the gender of the person taking responsibility for the household farming activities has no significant influence on household food security status in KCDM.

#### **8.4 Discussion**

The aim of this paper was to analyze the food security status of the small-scale farming households from two local municipalities, Mthonjaneni and uMhlathuze in KCDM. The lowest

proportion of the sampled farming households in Mthonjaneni, uMhlathuze and the combined analysis (KCDM) fall in the low dietary diversity category. These results agree with the findings of Taruvinga *et al.* (2013) and Muhammad-Lawal *et al.* (2017) that there are fewer farming households in the low dietary diversity category. In a study on the determinants of household food security in Maphumulo local municipality in KZN province, Ngema *et al.* (2018) reported that the highest proportion of households are in the medium dietary diversity category. This agrees with the finding of this study in Mthonjaneni municipality showing the highest proportion of the sampled farming households to be in the medium dietary diversity category but contradicts that of uMhlathuze showing the highest proportion of the sampled farming households to be in the high dietary diversity category.

There is a similar pattern for both Mthonjaneni and uMhlathuze Municipalities where the lowest proportion of households were in the lower dietary diversity category. However, a closer look at the results reveals that a higher (41%) proportion of the households in Mthonjaneni were in the medium category, while in uMhlathuze, a higher portion (39%) of the were in the higher dietary diversity category. This implies that uMhlathuze had more farming households in the high dietary diversity category than in the medium dietary diversity category, while the opposite is the case for Mthonjaneni. The possibility of access to alternative income sources as a result of more economic activities could be responsible for more sampled households being in the high dietary diversity category in uMhlathuze.

However, it is interesting to note that uMhlathuze had slightly more sampled farming households in the lower dietary diversity category than Mthonjaneni. The food security categorization of the households based on the HDDS (Table 8.4) shows that there are slightly more food secure households in Mthonjaneni than in uMhlathuze. This finding is consistent with the descriptive evidence on the TVP of the sampled farming households in both municipalities (Table 7.1\*) suggesting that the households in Mthonjaneni are more agriculturally productive than their counterparts in uMhlathuze. Findings from the combined analysis generally reveal that the majority of the sampled farming households in KCDM may be deemed as food secure.

Results from the HFCS analysis reveal that the majority of the sampled farming households in Mthonjaneni and uMhlathuze had an acceptable consumption score. The combined analysis also shows that the majority of the sampled households in KCDM had an acceptable consumption score. This result is in congruence with the result of the HDDS analysis. This

confirms the notion that high HDDS results in acceptable HFCS (International Food Policy Research Institute, 2008; Ngema *et al.*, 2018). The pattern of consumption in the last 24-hour dietary recall, as depicted in figure 8.2, reveals that cereals were the highest food group consumed by the sampled households. This could be because of availability and easier access to the food group in the study area/ s and the fact that the sampled households were more into cultivation of cereals. There is also a similar pattern for both municipalities for “fish and seafood” although this food group was not patronized as other food groups possibly due to preference for meat. The similarity in the pattern of consumption of the food groups between Mthonjaneni and uMhlathuze Local Municipalities could be as a result of the way of life of the residents in the study area/ s which are very closely related.

Findings from this paper reveal that the adoption of CSA practices would increase the chances of the food security of the sampled farming households in both municipalities under investigation. This is in line with the findings of Wekesa *et al.* (2018) on CSA practices and food security in smallholder production systems in Kenya that farmers who adopted CSA practices were more food secure than their counterparts who did not. Results from both municipalities suggest that mainstreaming CSA would impact the livelihood and food security status of small-scale farming households in KCDM.

The household size of the sampled households in both municipalities significantly and negatively influenced their food security status. The larger the household, the higher the chances of being food insecure. A similar pattern obtains for the dependency ratio of the households. This is expected as a high dependency ratio in a household means there are more household members who are not working than those that are working. Although we cannot attribute the number of non-working individuals in a household to the problem of unemployment, there is a high correlation between unemployment and high dependency ratio. A study by Ngema *et al.* (2018) shows a positive correlation between employment and food security. The more there are non-working individuals in a household, either due to unemployment or other reasons, the lower the chances of such households of being food secure.

Flow of income from farming engagements or non-farming sources significantly affected the food security status in both municipalities. The result suggests that an increase in income from farm and off-farm sources would increase the chances of the sampled households being food secure. This result is in contrast to the finding of Ngema *et al.* (2018) who reported a lesser likelihood of households being food secure with an increase in household income. It is expected

that more inflow of income will financially strengthen households in battling food insecurity which is corroborated by the findings of this paper.

Results from both municipalities show that the participation of household members in farming activities has a significantly positive influence on the food security status of the households. This suggests that households with sufficient labor resources are more likely to be food secure. The probable explanation is that sufficient labor would help in the timely conduct of farming activities which could result in high yields. This finding agrees with the submissions of Bogale and Shimelis (2009) and Mango *et al.* (2014). The farming experience of the household head also has a significant positive effect on its food security status in both municipalities. The explanation for this could be that productivity is expected to improve with an increase in years of experience, and in turn, improve food security status.

Gender emerged as a significant and positive influence on the food security status of the sampled households in Mthonjaneni. By contrast, it had no significant influence on the food security status of the sampled farming households in uMhlathuze. Results from Mthonjaneni Municipality suggest that households with males in charge of the household farming activities could be more food secure than the ones where females are in charge. The finding is in line with the report of Abdullah *et al.* (2019) that female-headed households are more vulnerable to food insecurity than male-headed ones. This suggests that female-headed households need more attention and help for improved livelihoods and to cope with food insecurity.

## **8.5 Conclusion and Policy Implications**

This study responds to the lack of consistent classifications of indicators for analyzing household food security among vulnerable groups in South Africa (Hendriks *et al.*, 2016). This paper contributes to the literature and evidence base by analyzing the food security status of small-scale farming households in the study area/ s based on dietary diversity. A greater proportion of the sampled households were in the medium and high dietary diversity categories and are therefore deemed to be food secure. The HFCS, likewise, also placed the majority of the sampled households in an acceptable consumption category, substantiating the result from the HDDS analysis.

Although the majority of the sampled farming households were found to be in the medium to high dietary diversity and acceptable food consumption category; not all the sampled households are truly food secure. There is still a fraction of farming households with low

dietary diversity scores that should be given adequate consideration. It is also important to note that achieving food security and ensuring its sustainability means guaranteeing continuous access to food – quantity and quality-wise – for present and future generations. Poverty, environmental factors, inconsistencies in policy formulation and implementation have been identified in studies to be the major factors militating against food security. This study argues that these challenges are surmountable and recommends that researchers be encouraged to work towards achieving increased food production and environmental friendliness.

There is a considerable gap in the literature and evidence base on the adaptation and mitigation potentials of different CSA practices and technologies in terms of their effects on the food security of vulnerable groups. This paper fills the gap in the literature and contributes to the evidence base by examining the effect of CSA adoption on the household food security status in small-scale production systems. The paper deviates from the conventional approach of focusing on a single practice but grouped practices that fit into CSA profile based on usage, and then examined the effects of the CSA adoption level on household food security. The study finds that household food security status in Mthonjaneni and uMhlathuze Municipalities is influenced by the adoption of CSA practices and other factors such as household size, dependency ratio in the household, farm income, income from off-farm sources, farming experience and participation of household members in farming activities, with gender as an additional determinant in Mthonjaneni.

Based on these findings, it is argued that the more small-scale farming households adopt CSA practices, the brighter their chances of being food secure. Considering this outcome in line with the empirical evidence obtained from the effect of CSA adoption on productivity, it is argued further that for small-scale farmers to maximize the benefits from CSA adoption, and also to enhance food security, they need to incorporate CSA practices as much as possible. Climate-smart agriculture has the potential to improve the alleviation of food insecurity among small-scale farming households. Small-scale farmers should be encouraged to adopt practices that are climate-smart and integrate as many practices as their capacity, know-how and operation can accommodate. Besides, it is expedient that more attention is given to households with females in charge of agricultural activities, female-headed households as well as households with high dependency ratios.

This paper recommends that policy design and implementation should involve sensitization on the need for investment in productive agricultural practices and assets. This will fortify farmers

against climate change related risks and enhance their ability to adopt CSA. The sensitization could be carried out through extension workers and platforms such as agricultural-related groups that farmers belong to. Secondly, given the positive influence of the involvement of the members of the sampled households on the food security status of the households, governments and organizations interested in agricultural development and other stakeholders should embark on projects that will make agriculture more attractive, particularly at the small-scale level. There is the need to do more in rebranding agriculture as a lucrative venture and not as a vocation for those without options. This is important for enhancing food security and poverty alleviation as well as agricultural and rural development in South Africa and many other African countries.

This paper also recommends, based on the positive influence of farming experience on food security, that national and local institutions should be strengthened to support farmers' by providing them with access to information and resources. Policies should make use of extension services for information dissemination in more attractive and productive ways, particularly with regard to using evidence to adapt practices to local conditions. Also, there is the need for policies and regulations for increased coordination of agricultural, environmental and food systems. An enabling policy environment facilitated by collaborations across relevant units is needed for enhancing the synergy which could usher in the desired outcome.

This paper recommends extending the research to other areas in South Africa. This will support effective decision making and make evidence widely accessible to decision-makers at the national and local levels. An extended scope into similar research will also help in addressing technical challenges associated with the upscaling of recommendations and models that will be needed for a more appropriate decision making. Researchers can also consider exploiting synergies from global, national and local studies for more robust and integrated findings. This study also recommends in-depth studies on factors that can influence the sustainability of household food security particularly in rural areas. This will provide more holistic understanding of the dynamics of food security and poverty among farming households. Furthermore, policies related to food security should be designed and implemented along with plans for the sustenance of such policies.

### **Author Contributions**

V.O.A. conceived and designed the study. V.O.A collected and analyzed the data for the study and drafted the manuscript. M.S. and A.O. supervised the study. M.S and A.O scrutinized and

verified the research process, methods and the manuscript. All authors contributed to the outcome of the manuscript.

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### **Conflict of interest**

The authors declare no conflict of interest.

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## CHAPTER NINE

### SUMMARY, CONCLUSION AND RECOMMENDATIONS

#### 9.1 Introduction

This chapter presents the summary, conclusion and recommendations of the study. The chapter focuses on the key results obtained in the study. Conclusions are drawn from the results, with recommendations based on the findings and conclusions.

#### 9.2 Summary

There is a low adoption of potentially beneficial CSA practices (Murray *et al.*, 2016; Makate *et al.*, 2018). This informs the need for robust studies that will enhance the understanding of what is applicable to different agro-ecologies and farming systems and what constitutes climate-smartness in different bio-physical and socio-economic contexts (Lipper *et al.*, 2014). It is against this background that this study was carried out. The study was conducted in the KCDM of KZN province of South Africa with a comparative analysis of Mthonjaneni and uMhlathuze Local Municipalities. The main aim of the study was to determine the effect of CSA on the food security status of small-scale farming households.

The specific objectives of the study were to:

1. Describe the extent of adoption of CSA practices by small-scale farming households in the study area/ s;
2. Determine the factors influencing the level of adoption of CSA practices by small-scale farming households in the study area/ s;
3. Assess the level of applicability of the CSA practices in the small-scale farming system in the study area/ s;
4. Examine the effect of the adoption of CSA practices on the productivity of small-scale farming households in the study area/ s;
5. Examine the effect of CSA practices on the food security status of the small-scale farming households in the study area/ s.

This study adopts a quantitative research approach which allows the use of econometric models as it is best suited for answering questions about the relationships between measured variables with the aim of explaining and predicting outcomes and phenomena. The study adopted a cross-

sectional research design which is time and cost-effective and enables rational and sound conclusions. A multi-stage random sampling method was used to collect data from 327 small-scale farming households in KCDM. The sample size comprised 218 and 109 small-scale farming households from uMhlatuze and Mthonjaneni Local municipalities, respectively to enable a comparative analysis between the two municipalities. Data were collected through a survey method by the administration of a structured questionnaire between August 2018 and January 2019, during working hours (08h00-16h00). Interviews were also conducted and lasted an average of 50 minutes. The ethical clearance for the study was issued by the University of Zululand. After collection the data was recorded and coded on Microsoft Excel spreadsheets and then exported to Statistical Package for the Social Science (SPSS) and STATA software for analysis.

Descriptive statistics were used to identify and assess the extent of use of CSA practices by small-scale farming households in the study area/ s. The ASUI was used to analyze the extent to which the households adopt CSA practices to cope with the effects of climate change. The composite score and gologit model were used to determine the factors affecting the level of use of CSA practices by the households. The OLS regression model was used to examine the effect of adopting CSA practices on the productivity of the households. The HDDS was used to determine the food security status of small-scale farming households in the study area/ s while a binary logistic regression model was used to assess the effect of the adoption of CSA practices on the food security status of the households.

### **9.2.1 Findings from Literature**

#### ***1. The extent of adoption of CSA practices in small-scale farming systems***

Despite its potentials, the small-scale farming system in Africa is highly vulnerable to climate change and variability (Pillay, 2016). This makes it imperative for small-scale farmers to embrace innovations that will help them cope and survive climate change. Gandure *et al.* (2013) report that most farmers in Sub-Saharan Africa, particularly those in areas with lower precipitation, have shifted from crops with high water level requirements to crops requiring a moderate level of water for cultivation. Crop farmers in areas with frequent flooding have adopted short-cycle crops and changed planting times to avoid periods with heavy rainfall (Abraham, 2018). Small-scale farmers have also adopted crop diversification, mixed cropping and also generate income from alternative sources (Sani *et al.*, 2016; Abraham, 2018). Small-scale farmers in the southern part of Africa where countries undergo severe water stress have

innovated water conservation techniques including water harvesting, wastewater re-use and irrigation (Gandure *et al.*, 2013; Sani *et al.*, 2016). Livestock farmers in Sub-Saharan Africa cope by digging boreholes in dry regions, diversify their income-generating activities and shift to livestock with a high tolerance for water scarcity and high temperature (Abraham, 2018).

## ***2. Factors influencing the level of adoption of CSA practices by small-scale farmers***

Climate change awareness has been established as a crucial pre-condition for climate change adaptation and mitigation (Juana *et al.*, 2013). Considering their vulnerability, farmers in developing countries are prime targets of education about climate change and its effects. Ojoko *et al.* (2017) report that education, membership of social group and access to credit were significant determinants of CSA adoption among small-scale farmers in Sokoto State in Nigeria. Akrofi-Atitianti *et al.* (2018) found that location of farms, farmers' age, residential status and access to extension services influence CSA adoption among cocoa farmers in Ghana. Aryal *et al.* (2018) noted that the biographical profile of farmers such as gender, education, social and economic capital, as well as farmers' experience of climate risks and access to extension services and training were critical determinants of CSA adoption among farmers in the Indo-Gangetic plains of India. Murray *et al.* (2016) argue for more attention to gender analysis while addressing the development and adoption of CSA tools and technologies.

## ***3. The applicability of CSA practices in small-scale farming systems***

The applicability of practices or technologies are the main challenges for mainstreaming CSA in different agro-ecological zones (Khatri-Chhetri *et al.*, 2017). Understanding applicability facilitates the planning and design of frameworks and structures meant to help farmers adapt to climate change and improve their resilience (Khatri-Chhetri *et al.*, 2017). There is the need for the consideration of adaptation practices that have been adequately evaluated and prioritized by local farmers concerning location-specific climate-related risks in planning CSA mainstreaming (Lipper & Zilberman, 2018). Farmers may be more interested in the applicability and immediate benefits that will accrue from CSA adoption than the long-term technical benefits it promises (Mwongera *et al.*, 2017).

## ***4. The effect of the adoption of CSA practices on the productivity of small-scale farmers***

Improvement in agricultural productivity is the result of efficient use of available physical, socioeconomic, institutional and technological resources (Onogwu *et al.*, 2017). The adverse effect of climate change has complicated the pressure on small-scale farmers in the Sub-

Saharan region to produce sufficient food for the region's growing population (Searchinger *et al.*, 2014). CSA comes with the potential of sustainably increasing agricultural productivity while reducing climate change vulnerability and the emissions that can cause climate change (FAO, 2013; Lipper *et al.*, 2014). CSA integrates ecological resilience with social resilience (Nwajiuba *et al.*, 2015).

### ***5. The food security status of small-scale farming systems***

Small-scale agriculture is dominated by low-income groups who focus on subsistence farming or integrate subsistence and cash crops (Tshuma, 2014). To a large extent, it operates on traditional know-how that is competitive based on low prices. Despite the limitations of small-scale agriculture, studies have pointed out that it contributes to food security and poverty alleviation (Gollin, 2014; Msangi, 2014). Msangi (2014) points out that many developing countries including South Africa are beginning to focus on small-scale agriculture as a way to combat food insecurity and rural poverty. This could be achieved by empowering the small-scale agricultural sector to create more employment and stimulate rural development. Simelane (2017) argues that the potential of small-scale agriculture to combat food insecurity and alleviate poverty is being underutilized and therefore advocates for more efforts in empowering small-scale farmers.

### ***6. The effect of the adoption of CSA practices on the food security status of small-scale farmers***

Climate change is a growing threat to food production and household well-being especially at the local level in many rural areas. It is exacerbating the problem of malnutrition, hunger and poverty (Lukano, 2013; Ncube *et al.*, 2016). The majority of the small-scale farmers in Africa depend primarily on farming for livelihood (Ochieng *et al.*, 2017). For the protection and sustenance of their livelihood and to ensure their food security, it is essential they build adaptive capacities and resilience towards climate change. Climate-smart agriculture focuses on alleviating food insecurity and the adverse impacts of changes in climatic conditions by facilitating resilient, sustainable agricultural systems which can increase food production, even under a changing climate (Kitsao, 2016). Climate-smart agriculture is an approach designed to transform and reorient agricultural systems to enhance food security under the realities of climate change. For small-scale farmers, CSA could lead to greater household food security, revenue increases and stronger resilience (Maguza-Tembo *et al.*, 2017).

## **9.2.2 A Summary of the Primary Findings**

### ***1. The extent of the adoption of CSA practices by small-scale farming households in King Cetshwayo District Municipality***

There is a major gap in the evidence base regarding technical issues associated with the downscaling of models to more applicable scales for policy designs and implementations at the local level, particularly as it relates to climate change issues. This makes it important to assess the views of farmers on the potentials of different agricultural practices with regard to adaptation and the mitigation of risks. This study fills this gap by evaluating the extent of the adoption of CSA practices by small-scale farming households in the study area/ s. This study reveals that there were more crop farmers than livestock farmers or farmers practising mixed farming among the sampled farmers. The use of organic manure and rotational planting of crops were the most frequently used CSA practices among the sampled crop farmers. Improved grazing was the most patronized CSA practice among the sampled livestock farmers while integrated crop-livestock management, diet improvement for animals and the use of organic manure were popularly adopted practices among those engaged in mixed farming.

### ***2. Determinants of the adoption of CSA practices by small-scale farming households in King Cetshwayo District Municipality***

This paper fills the gap in literature by identifying the factors affecting the adoption of CSA practices by small-scale farming households in the study area/ s. Educational status, average monthly farm income, farming experience, contact with agricultural extension agents, exposure to the media, marital status, agricultural production activity and the perception of the effects of climate change were factors with significant positive influence on the CSA adoption level of the respondents. Income from off-farm sources and the distance of farm to homestead had a significant and negative influence on the CSA adoption level among the sampled farmers.

### ***3. Assessing the applicability of CSA practices in the small-scale farming system of King Cetshwayo District Municipality***

In terms of how the sampled farmers perceive the social, technical, economic and environmental compatibility of CSA practices, the study reveal that practices such as rotational cropping, the planting of cover crops, efficient manure management, agroforestry, and diet improvement for animals had a high level of social acceptance. In terms of technical compatibility, the use of organic manure, rotational cropping, crop diversification, mulching

and cultivation of cover crops had a high level of acceptance. For economic compatibility, rotational cropping, mulching, the use of organic manure and cultivation of cover crops were highly accepted by the sampled farmers. And regarding the environment, the farmers found agroforestry, rotational cropping and the use of organic manure highly acceptable and compatible.

#### ***4. The effect of CSA adoption on the productivity of small-scale farming system: evidence from farming households in King Cetshwayo District Municipality***

It is important to evaluate the adaptation and mitigation potentials of different practices and technologies in agriculture from the local to global levels. In this regard, the study contributes to scholarship by exploring the contribution of CSA to the agricultural productivity of small-scale farming systems. This study deviates from the conventional approach of focusing on the effects of specific practices on agricultural production but grouped CSA practices on the basis of usage. This was followed by an analysis of the effects of the level of adoption of these practices on agricultural productivity. The study reveals that CSA adoption had a positive significant effect on the TVP of the sampled farmers. Likewise, factors such as household size, farming experience, contact with agricultural extension agents, exposure to media, gender, marital status, engagement in the integration of crop and livestock production and membership of an agricultural-related association or group had a significant positive effect on the TVP of the sampled farmers. By contrast, factors such as age, income from off-farm sources and engagement in livestock production was found to have a negative significant effect on the TVP of the sampled farmers.

#### ***5. The effect of climate-smart agriculture adoption on household food security in small-scale production systems: Evidence from King Cetshwayo District Municipality***

There is a major gap in the literature and evidence base regarding evaluations of the adaptation and mitigation potentials of different practices and technologies in agriculture in connection with the impacts on food security among vulnerable groups. This study fills this gap by examining the effects of CSA adoption on household food security in small-scale production systems. The study deviates from the conventional approach of focusing on a single practice but grouped CSA practices and examined the effects of the level of adoption of these practices on household food security. The study reveals that a high proportion of the sampled households were in the medium and high dietary diversity categories, implying that they are food secure.

The household food consumption score, likewise, also placed the majority of the sampled farming households in an acceptable consumption score substantiating the result from the HDDS analysis. The adoption of CSA practices significantly and positively correlates with the food security status of the sampled farming households. Farm income, income from off-farm sources, farming experience, participation of household members in farming activities also significantly and positively correlate with the food security status of the sampled households. By contrast, household size and dependency ratios significantly and negatively correlate with the food security status of the sampled farming households.

### **9.3 Conclusion**

Determining the applicability and impact of CSA in African agricultural systems, particularly the small-scale farming system, is crucial for a successful mainstreaming of CSA in the continent. Although many countries are expected to adopt CSA as a panacea to climate change, this is impossible if the African context remains understudied. The findings of this study are of great importance in contributing to knowledge on the factors affecting the level of adoption of CSA practices by small-scale farming households, the extent of adoption of CSA practices by small-scale farming households, the effect of the adoption of CSA on the productivity of small-scale farming households and the effect of CSA practices on the food security status of the small-scale farming households in the study area/ s.

As a novel approach, this study deviates from previous studies by going beyond the focus on a single CSA practice or project. Instead it examines multiple CSA practices. The analysis in the study extended to the level of CSA adoption among the sampled farmers and was not limited to the act of adoption alone. In addition, the study also deviates from the conventional approach of the sole focus on farmers' characteristics in adoption studies, to focus on the inherent characteristics of the CSA practices which could be of significant influence on adoption or transfer.

There are few studies which have been conducted on the potentials and dynamics of CSA adoption with respect to the small-scale farming system in South Africa. This study provides evidence on the dynamics of CSA adoption among small-scale farmers and the contribution of CSA to the South African small-scale farming system. Investigating the extent of CSA adoption among the sampled farmers reveal that small-scale farmers are making efforts to adjust and cope with climate change, portraying them as responsive and rational decision

makers. Farmers should not be overlooked and sidelined in the effort to identify problems in agricultural development.

The identified factors which influence CSA adoption levels in the two local municipalities separately and jointly in the district municipality include average monthly income from off-farm sources, which had a significant negative influence on the level of CSA adoption and contact with extension officer, the use of the media and perceptions of climate change which had a significant positive influence. A negative influence was from off-farm income sources which suggests farmers are more concerned about maximizing the income they earn. Increasing earnings through off-farm sources may be good for the households but it raises question about its effect on agricultural development. With the small-scale farming system being identified as crucial to agricultural and rural development, small- scale farmers finding succor from off-farm activities as alternative sources of income could impede the much-desired outcome. It is important that the government assists farmers to make farming more lucrative.

The finding of this study has established that contact with agricultural extension agents would enhance farmers' awareness of climate change and the practices that they can adapt to mitigate climate variability and shocks. Through agricultural extension and advisory services, farmers can learn climate change mitigation measures and strategies that can enhance resilience. The results from this study further establishes that farmers' exposure to the mass media increases the probability of uptake of CSA practices. With exposure to the media, small-scale farmers also have access to information that can facilitate their success in agricultural production. The use of media should not be overlooked in promoting innovative ideas and CSA adoption among small-scale farmers. The findings of this study on the perceptions of farmers on climate change shows that farmers who appreciate the risks of extreme and varying weather conditions will see the essence of adopting CSA practices. The awareness on the impacts of climate change and increasing farmers' exposure to the media and agricultural extension and advisory roles should be given adequate attention in mainstreaming CSA in the small-scale farming system.

The empirical evidence from this study shows a positive significant influence on agricultural productivity and food security of small-scale farming households. It also shows that CSA adoption has the potential of enhancing the much-desired increase in agricultural productivity and food security in the small-scale farming system. This establishes part of the goals of the concept of CSA which is to increase agricultural productivity and ensure food security under a changing climate. It is important to note that small-scale farmers should be encouraged to adopt

agricultural practices that are climate-smart and integrate as many practices as their capacity, know-how and operation can accommodate. Helping small-scale farmers adopt climate-smart practices in their agricultural production is a giant step towards improving agricultural productivity and enhancing household food security in the small-scale farming system.

## **9.4 Recommendations**

### ***1. Reinforcement, and better creative and productive use of extension services:***

There is the need to re-enforce and improve the use of agricultural extension services in more creative and productive ways. This study recommends improvement in the access of small-scale farmers to agricultural extension services. Policies should be designed and implemented in ways that extension services are more attractive and productive with regards to the dissemination of information concerning climate change adaptation and mitigation strategies. Frequent extension visits and services are very useful in mainstreaming CSA adoption among small-scale farmers. Furthermore, extension agents should increase their contacts with small-scale farmers and improve their extension and advisory roles with them to enhance the agricultural productivity in the small-scale farming system.

### ***2. Educating rural farmers on climate change and climate-smart techniques***

There is the need for awareness on climate change and climate friendliness beyond the academic and elite communities. Rural farmers should also be educated on climate change and the need for environmental friendliness in ways they can relate to. Policies should accommodate rural dwellers to mainstream climate friendliness in communities. Encouragement and assistance should be given to rural farmers on practices and techniques that are climate smart. Policies should also accommodate sensitization on the need for investment in productive agricultural practices and assets. National and particularly local institutions should be strengthened to support adaptive capacities through enhancing farmers' access to information and resources.

### ***3. Intensifying the use of and increasing access to Media***

Given its importance, there is the need to intensify the use of the mass media in propagating valuable agricultural information that can be of immense benefit to farmers and also improve the penetration and access of small-scale farmers to the media. The use of the media should be intensified in promoting awareness on climate change among farmers and information on

practices that can help them cope and adjust to its effects. The government and agricultural stakeholders should synergize their efforts in creating structures that will improve farmers' exposure to the media so that they can be well armed with essential and needed information.

#### ***4. Encouraging and maximizing farmers' groups for advisory roles and information dissemination***

Agriculturally related groups, associations or societies can be used as platforms to reach out to small-scale farmers for advisory roles and dissemination of information from governments or interested organizations. Available farmers' platforms should be used to educate farmers about climate change and practices that can help them cope with the challenges they face in agricultural production, particularly regarding climate change. Farmers should be considered as channels of information among themselves on climate change and CSA. By so doing, more farmers can adopt many CSA practices and techniques that will make their agricultural production systems more productive and resilient to climate change. Membership of agricultural related groups, associations or societies should, therefore, be encouraged among small-scale farmers.

#### ***5. Making agriculture more attractive for better income and youth participation***

The study highlights the need to make agriculture more attractive to increase the participation of youths, males and for better income. Policies should be directed towards making agriculture more attractive while incentives should be given to encourage active involvement in agriculture particularly to support small-scale farmers. The participation of agricultural-related organizations in campaigning for more involvement by youths and men in agricultural production is recommended. Governments and stakeholders in agricultural development should embark on programs that will make agriculture more attractive, particularly at the small-scale level. This is important for enhancing food security and poverty alleviation as well as agricultural and rural development in South Africa and many other African countries.

#### ***6. Involvement of farmers in framework design and implementation***

Based on the findings of this study, it is argued that understanding the pattern of adoption among farmers is essential for the successful mainstreaming of CSA related projects and empowering farmers, mainly the small-scale in achieving sustainable agriculture in the era of climate change. It is therefore recommended that policymakers and other agricultural stakeholders should involve farmers in agricultural development programs including those

focusing on combating climate change challenges right from the design stage. A bottom-top approach will be more effective in mainstreaming CSA as it will make implementation much easier amidst farmers.

### ***7. Mainstreaming CSA technology with adequate consideration given to location-specific factors***

Policies and programs aimed at promoting CSA among small-scale farmers should be driven with adequate attention given to the applicability of the considered CSA practices and programs in the target locations. Location-specific factors should be factored in program design and implementation for small-scale farming systems.

### ***8. Encouragement and enhancement of integration of crop-livestock farming among small-scale farmers***

A strong empirical evidence has shown that the integration of crop and livestock farming could improve agricultural productivity. Encouragement and assistance should be given to small-scale farmers for efficient integration of crop and livestock farming to boost their chances of improved productivity.

### ***9. Giving more attention to the sustainability of Food Security***

There is the need for increased coordination of agricultural, environmental and food system policies. An enabling environment facilitated by collaborations across relevant units is needed for enhancing the synergy which could promote the sustainable food security of households. Furthermore, policies related to food security should be designed and implemented with plans for sustenance.

### **9.5 Further research**

The dynamism in climate change, CSA and food security issues need further research and the following areas are recommended:

### ***1. Further investigation of CSA adoption on food security***

This study encourages further studies on the effect of CSA adoption on food security with the incorporation of other methods such as the adoption of cost-of-calorie as proxy measure for food security.

### ***2. The potential of indigenous knowledge system in climate-smart agriculture***

This study encourages researchers to further investigate CSA practices by undertaking similar research on indigenous practices adopted by local farmers, which can fit into the CSA framework and how they can be adapted for use in other areas.

### ***3. Evaluation of climate-smart agricultural programs and projects in the context of small-scale farming system***

This study encourages researchers to further investigate the contribution of CSA to agricultural productivity particularly in the small-scale farming system in South Africa. This research can be further taken further in terms of sample size and extension to other areas in South Africa to enhance the reliability of the findings. In addition, studies can be conducted to evaluate climate-smart projects and programs designed for small-scale farmers. This will provide a more holistic picture of the impacts of such projects especially on small-scale farming households.

### ***4. Active promoters and inhibitors of sustainable household food security***

This study recommends research into increased food production and environmental friendliness. This study also recommends in-depth studies on factors that can influence the sustainability of household food security, particularly in rural areas. This will provide the possibility for more holistic understanding of the dynamics of food security and poverty among farming households.

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## APPENDIX I: QUESTIONNAIRE

### UNIVERSITY OF ZULULAND FACULTY OF SCIENCE AND AGRICULTURE SURVEY QUESTIONNAIRE



My name is Abegunde Victor Oluwadamilare. I am a doctoral student at the University of Zululand, Department of Agriculture. I am doing a study entitled “Effect of Climate-Smart Agriculture on food security of farming households in KwaZulu-Natal Province”. I kindly request you to assist me by completing this questionnaire. I guarantee your anonymity and promise that you will not be identified in any manner. Thank you for your cooperation.

Questionnaire number: .....

Date of interview: .....

Municipality: .....

Name of village: .....

Name (Optional): .....

**A. SOCIO-ECONOMICS CHARACTERISTICS**

1. Age of household head: .....
2. Gender of household head: ..... Male = [1]; Female = [0]
3. Marital status of household head: Single = [1]; Married = [2]; Divorced/separated = [3]; Widowed = [4]
4. Educational status of household head: No formal Education = [1]; Primary = [2]; Secondary = [3]; Tertiary = [4]
5. How many years did you spend in school (in total)? .....
6. Household size: .....
7. How many of your household members fall into the following age group?

Age group (years)	Number of males	Number of females
< 15		
15 – 65		
> 65		

8. Number of dependants: .....
9. Number of household members employed.....
10. Number of household members unemployed.....
11. What is the average monthly income of your households from farming activities (ZAR)? .....
12. Average monthly expenditure on food (ZAR): .....
13. Average monthly expenditure on non-food items (ZAR): .....
14. What other income generating activities are your household members engaged in?

Activities	Amount generated (ZAR)	Frequency (use codes below)

**Codes: [1] = daily; [2] = weekly; [3] = twice a month; [4] = monthly; [5] = others (specify).....**

15. How many relatives outside your household were involved in farming discussion with you in the last farming season? .....
16. How long have you been into farming? .....
17. What is the average distance of your homestead to your farm(s) in kilometers? .....

18. Do you have access to agricultural credit? ..... Yes = [1]; No = [0]

19. If yes, indicate the source(s) of your credit and the amount obtained in the last cropping season.

Source of credit	Amount obtained (ZAR)	Interest paid (%) per year	Duration of credit
Agricultural Bank			
Commercial banks			
Local Money lenders			
Friends and Relatives			
Cooperatives			
Others (specify) .....			

20. How many times has an extension officer visited you? .....

21. How can you describe your contact with extension agents? .....

Very often = [1]; Often = [2]; Seasonally = [3]; Not at all = [4]

22. Do you usually have farmer-to-farmer extension visits in your community? Yes = [1]; No = [0]

23. What type of agricultural production activity are you engaged in? .....

Crop production only = [1]; Livestock production only = [2]; Both crop and livestock production = [3];

24. Do you belong to any association/social group? ..... Yes = [1]; No = [0]

25. How many associations/social groups do you belong to? .....

26. How long have you been a member of the associations/social group? .....

## B. HOUSEHOLD NON-FOOD EXPENDITURE

27. Please supply the following information on your expenses in the past **one (1)** month

S/N	ITEMS	AMOUNT (ZAR)
1	Clothing (fabric, clothes, towels, beddings)	
2	Shoes and foot wears	
3	Education (fees, books, school uniform)	
4	Health (medicine, glasses, Doctor's charges)	
5	Transportation cost	
6	Handset and GSM recharge card	
7	House rent	
8	Furniture (beds, tables, chairs)	
9	Kitchen utensils (pot, cup, plates, spoons, etc.)	
10	Cigarettes or tobacco, kolanut	
11	Recreational (cinemas, video/DVD rental)	
12	Petrol and engine oil, kerosene, charcoal, firewood, gas, candle	
13	Electricity bills (including purchase of light bulbs)	
14	Purchase of motorcycle/bicycle	
15	Home repairs (painting, roofing, etc.)	

16	Debt repayment (cooperatives, local contribution)	
17	Ceremony and entertainment (wedding, naming ceremony, funeral, etc)	
18	Donations to charity and religious activities	
19	Other taxes and levies (community levies, night guards)	
20	Others (specify).....	

**C. INFORMATION ON CLIMATE CHANGE**

28. Do you feel that the pattern of weather is generally changing around your environment? Yes = [1]; No = [0]

29. What have you observed about the temperature in your environment for the last five (5) years? Increasing = [1]; Decreasing = [2]; No change = [3]

30. What have you observed about the rainfall pattern in your environment for the last five (5) years? Increasing= [1]; Decreasing = [2]; No change = [3];

31. Does the rainfall pattern affect you when you plant your crops? Yes = [1]; No = [0]

32. What impact/effect, if any, do you think Climate change is having on your crop yield? Positive = [1]; Negative = [2]; No change = [3]

33. Have you perceived any change in temperature in your environment for the last five (5) years?

(i) Increased temperature Yes = [1]; No = [0] (ii) Low temperature Yes = [1]; No = [0]

34. Have you perceived any change in rainfall in your environment for the last five (5) years?

(i) Increased rainfall Yes = [1]; No = [0] (ii) Low rainfall Yes = [1]; No = [0]

35. Have you perceived any change in the duration of dry and wet season for the last five (5) years?

(i) Dry season Yes= [1]; No = [0] (ii) Wet season Yes = [1]; No = [0]

36. Which month of the year did rains start this season in your environment?

.....

37. How long does rain last in your environment? .....

38. What is the state of water supply in your area, as a result of this climate change?

Improved= [1]; Worsened = [2]; No change = [3]

39. Do you know any wetlands or water sources that used to have water and have since dried up in your area? Yes= [1]; No = [0]

40. Has your cropping activity been affected by drought in the last five (5) years? Yes = [1]; No = [0]

41. If yes, what is the magnitude of the effect of drought? mild= [1]; moderate = [2]; severe = [3]

42. Are the grasses/pastures around you supplying enough forage for your livestock to feed? Yes = [1]; No = [0]

43. Do you usually have access to information on climate change via?

<b>MEDIUM</b>	<b>YES</b>	<b>NO</b>
Radio		
Television		
Newspaper		
Internet		
Others (specify) .....		

**D. INFORMATION ON CLIMATE-SMART AGRICULTURE**

44. Please indicate your frequency of use in the table below by ticking the one applicable

<b>S/N</b>	<b>Climate-Smart Agriculture (CSA)</b>	<b>Frequently used</b>	<b>Occasionally used</b>	<b>Rarely used</b>	<b>Not used</b>
1	Conservation agriculture (minimum tillage, leaving crop residue on the field)				
2	Agro-forestry				
3	Use of organic manure				
4	Crop rotation				
5	Crop diversification (cereal/legume intercropping)				
6	Mulching				
7	Use of wetland				
8	Planting of drought and heat tolerant crops				
9	Planting of cover crops				
10	Soil conservation techniques				
11	Integrated Crop-Livestock Management				
12	Improved Grazing				
13	Efficient Manure Management				
14	Diet Improvement for Animals				

45. There is satisfaction with the CSA practices, considering the identified conditions

	<b>Climate-Smart Agriculture (CSA)</b>	<b>Culture and social norms/ Gender biasness</b>	<b>Ease of adoption and application</b>	<b>Cost of adoption</b>	<b>Effect of adoption on production and the environment</b>
1	Conservation agriculture (minimum tillage, leaving crop residue on the field)				
2	Agro-forestry				
3	Use of organic manure				
4	Crop rotation				
5	Crop diversification (cereal/legume intercropping)				
6	Mulching				
7	Use of wetland				

8	Planting of drought and heat tolerant crops				
9	Planting of cover crops				
10	Soil conservation techniques				
11	Integrated Crop-Livestock Management				
12	Improved Grazing				
13	Efficient Manure Management				
14	Diet Improvement for Animals				

**SD: Strongly Disagree, D: Disagree, N: Neutral, A: Strongly Agree, SA: Strongly Agree**

### E. HOUSEHOLD LIVESTOCK PRODUCTION

46. State the types and the number of livestock you have in stock presently. Indicate the amount of income you generate from each type per year. (Include the income from eggs in the case of birds).

LIVESTOCK	CURRENT NUMBER IN STOCK	NUMBER SOLD LAST YEAR	INCOME FROM SALES (ZAR)
Cattle			
Sheep			
Goat			
Poultry			
Others .....			
.....			

### F. CROP PRODUCTION

47. How did you acquire the plot of land you are farming on? Inherited = [1]; Rented = [2];

Purchased = [3]; Gift = [4]

48. How many plots of land do you have? Complete the table below:

Plot No.	Crops grown	Size in Hectares
<b>Total Plot size</b>		

49. Which of the crops in 'question 47' above is the major crop grown on your farm?

.....

50. Which type of seeds did you plant on your farm in the last farming season?

.....

Improved variety = [1]; Local seeds = [2]; Mixture of both improved and local varieties = [3]

51. Which of the following cropping system(s) do you practice? Mixed cropping = [1]; Mono cropping = [2]; Relay cropping = [3]; Intercropping = [4]; Others (specify)..... = [5]

52. Labor use on the farm during the last cropping season:

Operations	Family labor				Hired labor			Communal/Exchange labor			
	Days used	Adult male (≥15years)	Adult female (≥15years)	Children (≤14 years)	Days used	Number of Persons hired	Cost of labor (ZAR) (wage rate)	Number of Persons	Hours/Day	Days used	Cost (ZAR) (if any)
Land preparation											
Planting											
1 <sup>st</sup> Weeding											
2 <sup>nd</sup> Weeding											
1 <sup>st</sup> Fertilizer application											
2 <sup>nd</sup> Fertilizer application											
Organic manure application											
Herbicide application											
Harvesting											
Threshing											
Transportation											
Others (specify) .....											

53. What quantity of the following farm inputs did you used in the last farming season and what was the cost incurred?

<b>Inputs</b>	<b>Quantity</b>	<b>Price/unit (ZAR)</b>	<b>Total Cost (ZAR)</b>
Seeds (Kg)			
Inorganic Fertilizer (Bags) • NPK • Urea			
Manure (Kg)			
Labor (man hours/day)			
Pesticide (Liters)			
Herbicides (Liters)			
Animal traction or tractor hiring			
Equipment (hoe, cutlass, tractor, etc.)			
Others (specify) .....			

54. In the table below, state the type(s) of crop and quantity produce for each type

<b>CROPS</b>	<b>Quantity Harvested in Kilogram</b>	<b>Quantity Harvested in bag(s)</b>	<b>Quantity sold</b>	<b>Amount sold (ZAR) (sales)</b>	<b>Quantity consumed</b>	<b>Quantity given out as gift (if any)</b>	<b>Quantity stored</b>
<b>CEREALS</b>							
Maize							
Sorghum							
Rice							
<b>LEGUMES</b>							
Cowpea							
Groundnut							
<b>OTHER CROPS</b>							
Vegetables							
Green Pepper							
Chilies							
Tomato							
Potato							
Sugar cane							
Onion							

### G. Household Food Security

55. Indicate if you consume any of these food groups in the last 24 hours

	Food Groups	Examples	Yes =1 No = 0
1.	Cereals	Maize, rice, wheat, sorghum, millet or any food made from these or other grains e.g. porridge, bread, noodles, putu pap	
2.	Roots and Tubers	Potatoes, cassava, manioc or any food from roots or tubers	
3.	Vegetables	Spinach, cabbage, lettuce, carrot or any other vegetable	
4.	Fruits	Orange, banana, pawpaw, pineapple and any other fruit	
5.	Meat, Poultry and Offal	Beef, pork, lamb, goat, rabbit, wild game, chicken, other birds, liver, kidney, heart or meats from other organs	
6.	Eggs	Eggs from chicken, duck, guinea fowl or any other egg	
7.	Fish and Seafood	Fresh or dried fish or shellfish	
8.	Pulses, Legumes and Nuts	Beans, peas, lentils, nuts or any food made from them	
9.	Milk and Milk Products Foods such as	Cheese, yoghurt, milk or any milk product	
10.	Oil and Fats	Oil, fats or butter added to food or used for cooking	
11.	Sugar and Honey	Sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies and cookies	
12.	Miscellaneous	Any other foods such as condiments, coffee or tea	

56. Did you or anyone in your household eat anything (meal or snack) outside the home in the last 24 hours?

57. Indicate if you have consumed any of these food groups in the past 7 days

	Food Groups	Examples	Day						
			1	2	3	4	5	6	7
1.	Main staples	Maize, rice, wheat, potatoes, cassava etc.							
2.	Pulses	Beans, peas, lentils, nuts etc.							
3.	Vegetables	Spinach, cabbage, lettuce, carrot etc.							
4.	Fruits	Orange, banana, pawpaw, pineapple etc.							
5.	Meat/Fish	Beef, pork, lamb, goat, rabbit, wild game, chicken, fresh or dried fish or shellfish etc.							
6.	Milk	Cheese, yoghurt, milk or any milk product							
7.	Sugar	Sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies and cookies							
8.	Oil	Oil, fats or butter added to food or used for cooking							

58. In the past **7 days**, if you did not have enough food or money to buy food in your household, how many days did your household had to:

S/N	Coping strategies	Frequency of usage (Days) <sup>(a)</sup>
1	Skip meals	
2	Eat less preferred meals	
3	Beg for food	
4	Borrow food from friends and relatives	
5	Purchase food on credit	
6	Reduce the quantity of food consumed	
7	Restrict consumption by adults to enable children eat	
8	Consume seed stock held for next season	
9	Send household members to eat elsewhere	
10	Gather wild food (Fruits)	

<sup>(a)</sup>Frequency: Never/ week = [0], One day in a week = [1], Two days in a week = [2], Three days in a week = [3], Four days in a week = [4], Five days in a week = [5], Six days in a week = [6], Seven days in a week = [7]

59. Do you think climate change has significant adverse impact on your production?

Yes = [1]; No = [0]

60. State the constraints/challenges you face in using Climate-Smart Agricultural practices

.....

.....

.....

.....

.....

.....

**Thank you for the anticipated kind gesture.**

## APPENDIX II: ETHICAL CLEARANCE CERTIFICATE

**UNIVERSITY OF ZULULAND  
RESEARCH ETHICS COMMITTEE**  
(Reg No: UZREC 171110-030)



**RESEARCH & INNOVATION**

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### ETHICAL CLEARANCE CERTIFICATE

<b>Certificate Number</b>	UZREC 171110-030 PGD 2018/222					
<b>Project Title</b>	EFFECTIVE OF CLIMATE-SMART AGRICULTURE ON FOOD SECURITY OF SMALL-SCALE FARMING HOUSEHOLDS IN KING CETYWAYO DISTRICT MUNICIPALITY, KWAZULU-NATAL PROVINCE					
<b>Principal Researcher/ Investigator</b>	VO Abegunde					
<b>Supervisor and Co-supervisor</b>	Dr M Sibanda			Prof A Obi		
<b>Department</b>	Agriculture					
<b>Faculty</b>	Science and Agriculture					
<b>Type of Risk</b>	Med Risk– Desktop, field work or laboratory					
<b>Nature of Project</b>	Honours/4 <sup>th</sup> Year	Master's	Doctoral	x	Departmental	

The University of Zululand’s Research Ethics Committee (UZREC) hereby gives ethical approval in respect of the undertakings contained in the above-mentioned project. The Researcher may therefore commence with data collection as from the date of this Certificate, using the certificate number indicated above.

- Special conditions:**
- (1) This certificate is valid for 3 years from the date of issue.
  - (2) Principal researcher must provide an annual report to the UZREC in the prescribed format [due date-July 2019]
  - (3) Principal researcher must submit a report at the end of project in respect of ethical compliance.
  - (4) The UZREC must be informed immediately of any material change in the conditions or undertakings mentioned in the documents that were presented to the meeting.

The UZREC wishes the researcher well in conducting research.

*Gideon De Wet*  
**Professor Gideon De Wet**  
 Chairperson: University Research Ethics Committee  
 Deputy Vice-Chancellor: Research & Innovation  
 09 July 2018

**CHAIRPERSON**  
 UNIVERSITY OF ZULULAND RESEARCH  
 ETHICS COMMITTEE (UZREC)  
 REG NO: UZREC 171110-30

12-07-2018

**RESEARCH & INNOVATION OFFICE**